The Royal Aeronautical Society

(FOUNDED 1866)

with which is incorporated The Institution of Aeronautical Engineers

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R 101

His Majesty's rigid airship R 101 left Cardington on Saturday, October 4th, at 7.35 p.m. Shortly after 2 a.m. on Sunday morning, October 5th, the airship crashed near Beauvais, catching fire, with a resulting loss of forty-eight lives. A list of those who perished appears on page 896, and biographical notices of those who were members of the Society on page 897.

"And now they have died together, and with them has gone a great treasure of gathered knowledge and invaluable experience."

R 101

The following are the names of those who lost their lives in the R 101 disaster. The members of the Society who perished are commemorated elsewhere in this issue of the Journal:—

PASSENGERS.

Brig.-General the Right Hon. Lord Thomson, P.C., C.B.E., D.S.O., Secretary of State for Air.

Air Vice-Marshal Sir W. Sefton Brancker, K.C.B., A.F.C., Director of Civil Aviation.

Wing-Commander R. B. B. Colmore, O.B.E., R.A.F., Director of Airship Development.

Lieut.-Colonel V. C. Richmond, Assistant Director of Airship Development (Tech.).

Major G. H. Scott, C.B.E., A.F.C., Assistant Director of Airship Development (Flying).

Major P. Bishop, O.B.E., Chief Inspector, Aeronautical Inspection Department, Air Ministry.

Squadron Leader F. M. Rope (attached to Directorate of Airship Development).

Mr. A. Bushfield, Aeronautical Inspection Department.

Squadron Leader W. H. L. O'Neill, M.C., R.A.F., representing the Secretary of State for India.

Squadron Leader W. Palstra, M.C., representing the Royal Australian Air Force.

Mr. J. Buck, in attendance on the Secretary of State for Air.

OFFICERS.

Flight-Lieut. H. C. Irwin, A.F.C., R.A.F., Captain.

Squadron Leader E. L. Johnston, O.B.E., A.F.C., R.A.F., Navigator.

Lieut.-Comdr. N. G. Atherstone, A.F.C., (R.N. Ret.), 1st Officer.

Flying Officer M. H. Steff, R.A.F., 2nd Officer.

Mr. M. A. Giblett, M.Sc., Superintendent of Airship Division, Meteorological Office, Meteorological Officer.

CREW.

G. K. Atkin, wireless operator.
R. Blake, engineer.
C. A. Burton, engineer.
S. Church, rigger.
C. J. Ferguson, engineer.
H. E. Ford, rigger.
P. A. Foster, rigger.
W. R. Gent, A.F.M., first engineer.
E. A. Graham, cook.
A. C. Hastings, engineer.
F. Hodnett, assistant steward.
G. W. Hunt, A.F.M., chief coxswain.
S. T. Keeley, chief wireless operator.
T. A. A. Key, charge-hand engineer.
W. H. King, engineer.
F. Elliott, wireless operator.
M. F. Littlekit, engineer.
C. H. Mason, assistant coxswain.
J. W. Megginson, galley boy.
W. Moule, engineer.
A. W. J. Norcott, rigger.
L. F. Oughton, assistant coxswain.
W. A. Potter, assistant chief coxswain.
W. G. Radcliffe, rigger.
M. G. Rampton, rigger.
A. J. Richardson, rigger.
E. G. Rudd, rigger.
A. H. Savidge, chief steward.
S. E. Scott, charge-hand engineer.
G. W. Short, charge-hand engineer.
C. E. Taylor, rigger.
A. H. Watkins, engineer.

Per Ardua ad Astra.

Lord Thomson of Cardington, P.C., C.B.E., D.S.O.

Secretary of State for Air, *Companion*

Lord Thomson of Cardington was the third son of Major-General David Thomson, R.E., and was born on April 13th, 1875. Educated at Cheltenham, he passed into Woolwich and was gazetted to the Royal Engineers in March, 1894. He saw active service in Mashonaland in 1896, and again in 1899 during the South African War. He was one of the officers engaged in the relief of Kimberley. In 1902 he became Assistant Instructor at the Engineering School at Chatham and entered the Staff College in January, 1909. In 1912 Thomson was sent to the Serbian Army and remained with them throughout the campaign against the Turks and the war with Bulgaria. In August, 1914, he sailed for France with Sir Henry Wilson. For a while he served as a liaison officer, followed by some weeks at Belgian Headquarters and afterwards with the Staff of the 1st Corps of the B.E.F. In February, 1915, he became the first Military Attaché at Bucharest, and then head of the British Mission after Rumania entered the war. In 1917, on his return to England, after superintending the destruction of the Rumanian oil wells, he went to Palestine as C.R.E. of the 60th Division. In 1918 he went to France on the Supreme War Council, and remained at Versailles until 1919.

In that year, with the rank of Brigadier-General, he retired from the Army and joined the Labour Party, and in January, 1924, he became the first Labour Air Minister, and was created Lord Thomson of Cardington.

Brief though the period was that Lord Thomson was first in office he left his mark on aviation, and the air world saw in him a Minister who took far more than an academic interest in his post. During his few months of office in 1924 the Air Estimates were considerably increased, airship development, which was at a standstill, was begun afresh, and the plans for R.100 and R.101 were prepared. He travelled regularly by air on visits of inspection, until the fall of the Government in the autumn of 1924. On the return of the Labour Party to power, in 1929, Lord Thomson again became Air Minister, and saw the plans he had prepared in 1924 come to fruition during his second period of office.

Lord Thomson, in his farewell message to the staff of the Air Ministry in 1924, stated his belief in the unlimited potentialities of aviation both in peace and war. He was insistent that the air is the first line of defence, and he consistently fought for the development of the Royal Air Force. And perhaps the side in which he was most interested, and for which he gave his life, was the development of the airship.

Lord Thomson joined the Society in 1927 and took an active interest in its work. It was characteristic of him that the day before his death he sent a message to the retiring President, Colonel the Master of Sempill, on relinquishing his office, and one to the new President, Mr. Fairey, on taking over his new duties.

Air Vice-Marshal Sir William Sefton Brancker, K.C.B., A.F.C.

Director of Civil Aviation. *Fellow*

Air Vice-Marshal Sir William Sefton Brancker was born on March 27th, 1877, and was the eldest son of the late Colonel W. G. Brancker, C.B., R.A. Educated at Bedford he passed into Woolwich and was commissioned in the Royal Artillery in 1896. He served in the South African War, was wounded and mentioned in dispatches. From 1903-1912 he served in India in artillery and other staff appointments. It was during this period, in 1910, he made his first flight, as a military observer, in a 50 h.p. Bristol box-kite. From that moment the air held him as nothing else. He learnt to fly on a Vickers biplane,

taking his certificate in June, 1913. At the beginning of the war Sir Sefton Brancker became Deputy Director of Military Aeronautics; in 1916-17, Director of Air Organisation; Commander, R.F.C., Middle East, 1917; Major-General, R.A.F., 1918; Controller-General of Equipment and Master-General of Personnel on the Air Council, 1918.

After the war Sir Sefton Brancker turned his attention to civil aviation, for which he saw a future far transcending military aviation. He resigned his appointment as Master-General of Personnel and joined the late Mr. Holt Thomas in the Aircraft Manufacturing Company. In August, 1919, the first regular air service between London and Paris began, and Sir Sefton Brancker threw the whole of his energy into focussing public and official opinion upon the possibilities and importance of the new form of transport. In those early days he carried out an amazing amount of missionary work.

In May, 1922, he was appointed Director of Civil Aviation, a post he held until his death. In his new post Sir Sefton Brancker had opportunities to push forward with his dreams of Imperial Air Communications and his visions of Civil Air Transport. He travelled everywhere by air, and in November, 1924, made a flight to India for the express purpose of surveying the projected airship route. During the succeeding years he encouraged every branch of civil aviation, not only on the commercial side, but on the sporting side. He was to be found at most light aeroplane club meetings, and his latest activity was to encourage the gliding movement under the British Gliding Association.

Created a K.C.B. in 1919, Sir Sefton Brancker was gazetted Air Vice-Marshal in the Reserve of Air Force Officers in 1924. He joined the Society in 1913, became a Fellow in 1925, served some years on the Council, was Chairman 1926-27 and Past-President from 1927-1930. It was during his term of office as chairman that the Society began to make real progress. Although Director of Civil Aviation he found time to preside at Council meetings and lectures, to lecture himself and to attend to the thousand and one details of the Society's organisation. The Royal Aeronautical Society owes a great debt to Sir Sefton Brancker. The last Council meeting he attended was on September 30th, but a few days before his death, when he promised to lecture before the Society.

The following is an extract from an appreciation by Mr. C. G. Grey of Sir Sefton Brancker:—

" Few of those many who have come to know Sefton Brancker of late years as the ideal Director of Civil Aviation of the moment know the true debt which the nation owes to him. They think of him as a cheery soul, the life of the party at a flying meeting, and after, who at the same time was strong enough and serious enough to thrust aside or cut through official regulations and get things done in a fraction of the time which would be taken by a typical civil servant. But they do not think of him as one of the men who did most to save the British Army in those difficult days of 1914 and early 1915.

" Major Brancker was at the War Office in the new department of Military Aeronautics. On him fell the task of getting the material that Colonel Trenchard needed, and he went at the job with all the energy which was part of his nature. There is an old saying that time finds the man—and certainly the right men were found in Colonel Trenchard and Major Brancker. And we have a very recent dictum of Marshal of the R.A.F., the Lord Trenchard, that no man did as much to build up the Royal Flying Corps as did Sefton Brancker. None could wish for a better epitaph.

" The good he has done has never been properly estimated. Thanks to him the Flying Club movement, originated by Sir Geoffrey Salmond and so carefully fostered by Sir Samuel Hoare, has flourished in a way which is the envy of all other nations. Sir Sefton Brancker has been to pretty nearly every

flying meeting in the country since he held office. And he was regarded as a personal friend by every official of every club.

" Abroad Brancker was just as valuable an asset. He never let any foreigner think that British aviation was anything other than the very best in the world. He worked furiously hard, and he played as furiously hard, and he took an almost equal pride in each. His energy was seemingly inexhaustible. He could do a man's day's work in his office, fly hundreds of miles, dance all night, and turn up merry and bright for work in the morning, and do it all over again. His was a most confusing character. We shall all miss him terribly. He was certainly not cut out for a peaceful old age. That he should go in the fulness of his powers and of his popularity is far better.

" There's something in the theory, just made popular in *The Bridge of San Luiz Rey,* that each of us dies at the right time. Perhaps civil aviation no longer needs a leader of Brancker's type. Whatever may be, we must recognise the debt that we owe Sefton Brancker. And those of the younger generation of his friends, who called him familiarly ' little Branks,' may be better for understanding that in him they have known, at any rate, one man who has done good work as a soldier and as a civil servant for his King and for the people of this Empire."

Major George Herbert Scott, C.B.E., A.F.C., *Fellow*

Major George Herbert Scott was born in 1888 and educated at Richmond School, Yorkshire, and the Royal Naval Engineering College, Keyham. In 1914 he joined the Royal Naval Air Service as a Flight Sub-Lieutenant and served on the airship stations at Farnsworth and Kingsnorth. In 1915 he went to Barrow and was appointed to the command of the Parseval P.4. In 1917 he became the captain of the first British rigid airship, R.9. In 1918 he was appointed to command R.34, and was in command when the airship made the momentous crossing, in 1919, to the United States and back, the first double crossing of the Atlantic by air. For this great pioneer flight Scott received the C.B.E.

In 1920 Major Scott was appointed to the technical staff of the Royal Airship Works, at Cardington, and here he carried out his work on the mooring mast systems which now stand as monuments to his genius at Cardington, Cairo, Karachi and St. Hubert. Scott's inventive ability made it possible for airships to moor in the open for days on end in any weather. In 1924 he was appointed Officer in Charge of Flying and Training in the Airship Directorate, and in January, 1930, Assistant Director (Flying).

It was under Scott's direction that the trials of R.100 and R.101 were carried out, and he was the officer in charge on the recent flight of the former ship to Canada and back. Major Scott joined the Society in 1926 and was a Fellow. He served on the Council and was awarded the R.38 Memorial Prize in 1923 for his joint paper with Lieut.-Colonel Richmond, entitled " A Detailed Consideration of the Effect of Meteorological Conditions on Airships." He read a number of papers before the Society on the mooring and handling of airships, which have become standard papers on the subject.

By the death of Major Scott we have lost a great airship captain, a great airship pioneer and a great airship enthusiast. A man of singular charm and modesty, he had a wide experience of which, in the ordinary way, he said very little. He was undismayed by set-backs, always heartening those with whom he was associated by his constant cheerfulness and ready willingness to work unceasingly for the cause he had at heart. He had a sense of modesty in the extreme, never claiming any credit for himself, always willing to take the post of responsibility and danger.

Lieutenant-Colonel Vincent Crane Richmond, O.B.E., *Fellow*

Lieutenant-Colonel Vincent Crane Richmond was born on January 21st, 1893, and was educated at the Royal College of Science. Before the war he was an engineer to Messrs. S. Pearson and Sons, engaged on physical and structural problems in connection with dock construction. In 1915 he joined the Royal Naval Air Service and was chiefly concerned with the construction of non-rigid airships. He went to Germany in 1920 with the Inter-Allied Commission of Control, and was for part of the time in charge of the Naval Sub-Commission for the surrender of airships and seaplanes. In 1921 he was appointed to the Airship Research Department at the Air Ministry, and for two years was engaged on research problems connected with rigid airship construction. In 1923 he became a lecturer on airship design and construction at the Imperial College of Science. In 1924 he was appointed the officer in charge of design and research at the Royal Airship Works, and from that time was concerned chiefly with the design of R.101. In 1930 he was appointed Assistant Director (Technical) of Airship Development.

Lieut.-Colonel Richmond joined the Society in 1920 and became a Fellow in 1929. In 1923 he was awarded the R.38 Memorial Prize for his joint paper with Major Scott, entitled "A Detailed Consideration of the Effect of Meteorological Conditions on Airships."

He read a number of papers before the Society on the development of the rigid airship, which are classic.

Lieutenant-Colonel Richmond was a man of great personal charm and modesty. As the one chiefly responsible for the design of R.101 he was subjected to much criticism, much ill-informed, and he felt his position keenly in that it prevented him from replying. He had an extraordinarily sound judgment and a great breadth of view, and he was always ready to listen to sound criticism and to benefit by it. His papers read before the Society were models of what papers should be. Richmond rose to the high position he held by sheer ability and persistence of character. Richmond took every single precaution he knew to ensure the safety of the great ship which was largely the creation of his genius, and by his loss airships have lost one who will go down in aeronautical history as one of the great pioneers of airship development.

Squadron-Leader Frederick Michael Rope, *Associate Fellow*

Squadron Leader Frederick Michael Rope was born in 1888 and educated at Shrewsbury School and Birmingham University. Until 1912 he was an engineer to the British Electric Plant Company, Alloa. In 1913 he was employed on locomotive engineering on the Brighton Railway, and in 1915 he joined the Royal Naval Air Service. He served at the Capel and Kingsnorth Air Stations and later as staff officer in the Department of the Director of Research. At Capel he was responsible for engines of the S.S. and coastal airships and at Kingsnorth for similar work and engine accessories and in charge of wind tunnel work. From 1921-1924 he was Technical Staff Officer at Air Headquarters, Iraq, and on his return to England he was appointed to the Royal Airship Works, at Cardington. Squadron Leader Rope joined the Society as an Associate Fellow in 1919.

Of a singularly quiet disposition he achieved what he wanted from those above or below him by sheer quiet charm and determined constancy of purpose.

He was a remarkably steady experimenter and observer in flight, a quality rather rare in those of such active imagination.

His inventions contributed greatly to the success of the ship. He could define the requirements exactly and grasped the mechanical principles of design

so clearly that almost all his designs, even those of startling novelty, were right the first time or required only correction in detail.

Beyond his refusal to claim credit for what he had done, one found it difficult to get him to admit credit.

His one test for a thing—technically or morally—was whether it was right.

Of all the good airship men who have been lost he leaves a gap which will be most difficult to fill.

Major Percy Bishop, M.B.E., *Associate Fellow*

Percy Bishop was born in 1888 and educated at Kendrick School, Reading, at the Regent Street Polytechnic, and Sheffield University. He was apprenticed to Clement Talbot, Ltd., and later served with the Sheffield Simplex Company and with D. Napier and Sons, Ltd. He joined the Royal Aircraft Factory in 1912 as a designer and afterwards as chief inspector. In 1915 he received a commission in the Royal Flying Corps. He was awarded the M.B.E., both civil and military, in 1919 in recognition of his services. He continued with the Directorate of Aeronautical Inspection and became Chief Inspector, Aircraft.

Major Bishop was an active and keen member of the Society and served on one of its most important committees of Council, the Grading Committee. He was elected an Associate Fellow in 1918.

The following is an abstract from the *Times* of a tribute paid to Major Bishop by Dr. A. P. Thurston, a personal friend of long standing:—

"As Chief Inspector of Aircraft in the Aeronautical Inspection Directorate, Bishop was known and respected by the heads of every works throughout the land producing material or parts used in or in connection with aircraft. He was a Berkshire man of typical yeoman stock. His chief characteristics were an intense and unfailing kindness, and an understanding of men, coupled with loyalty and highly efficient practical knowledge of automobile and aeronautical engineering. This knowledge was gained in the works of Clement Talbot, the Sheffield Simplex, D. Napier and Sons, and the Royal Aircraft Factory. He possessed also the shrewdest common sense, and it is no secret that his advice was often sought by those in high authority as well as by leading manufacturers.

"His interest in aeronautics began in 1910, when he attended a course of my lectures at Sheffield University. On the outbreak of war he was placed in charge of the Inspection Department of the Royal Aircraft Factory, at Farnborough, where his ability was soon recognised by the officers of the Military Aeronautics Directorate. During this period he invented various scientific instruments for accurately gauging aeroplane parts, and wrote a paper which has become a classic.

"He was essentially an aeroplane man—that is, he believed in heavier-than-air craft—but, such was his devotion to duty, he took every possible step to become acquainted with the construction and operation of airships. He attended as one of the British representatives the Fifth International Conference on Aeronautics at the Hague."

PROCEEDINGS

FOURTH MEETING, SECOND HALF, 65TH SESSION

The Fourth Meeting of the 65th Session of the Royal Aeronautical Society was held in the Lecture Hall of the Royal Society of Arts, 18, John Street, Adelphi, W.C.2, on Thursday, February 13th, 1930, when a paper on the Autogiro, by Senor J. de la Cierva was read and discussed. The President (Colonel the Master of Sempill) was in the chair.

The CHAIRMAN: They had all come there that evening with a good deal of enthusiasm and were anxious to give Senor de la Cierva a very hearty welcome. Many of them were there at the end of 1925, shortly after Senor de la Cierva came to England, when he gave them the first detailed pronouncement on his invention, the autogiro. That lecture followed only a few days after the tests that had been made before the Aeronautical Research Committee and Air Ministry officials at Farnborough. That was in October, 1925. Senor de la Cierva was very distinguished in his own country, and was very well-known in all other countries. Last year the School of Aeronautical Engineering was founded in Madrid and one of the first acts performed by that school when it came into being was the conference of an Honorary Degree upon Senor de la Cierva.

Senor de la Cierva's first idea of the autogiro arose from his witnessing the stalling of a large three-engined machine. He decided to produce a type of aircraft which would be free from that danger. It was rather like the way Dr. Lachmann conceived his idea of the slotted wing during the war, after he had recovered consciousness in hospital following a serious crash which nearly cost him his life.

Whatever their ideas might be as to the ultimate future of the autogiro—many different ones, no doubt, would be expressed in the discussion—they were all at one on this point, that Senor de la Cierva, during his few years in England, had earned their admiration for his ability, his courage and his pertinacity. He was a very gifted person because he was not only the inventor of that type of aircraft, but in the main the designer, and in all cases, since the very first tests (after which he had learned to fly) he had been the pilot. Of the fourteen types which had been produced recently in this and other countries, the inventor and designer, Senor de la Cierva, had himself made all the first tests; so he at least had absolute confidence in his own invention.

THE AUTOGIRO

BY

J. DE LA CIERVA

(Ingeniero de Caminos, Canales y Puertos e Ingeniero de Construcciones Aeronáuticas)

I have, for the second time, the honour of addressing you. Four years ago I told you how I had had the good fortune to discover a new method of flying with characteristics altogether different from the conventional aeroplane.

To-day, taking advantage of your kind invitation, I come to tell you of how the crude experimental autogiros of 1925 have been developed into practical flying machines. I will also deal with a number of theoretical points in justifica-

tion of the assertions I have often made about the qualities of the autogiro and in answer to the criticisms of which my system has been made the object from time to time.

I have, at the risk of giving the impression of not understanding my own discovery, preferred to remain practically silent for years, giving only expression to my faith in the future. I was waiting to have enough experimental evidence to check my theories, which I have not had until quite recently, because of the secondary difficulties which make any development of this kind so slow and painful. A double simultaneous investigation, aerodynamical and mechanical, has been necessary to bring the autogiro to the present stage, which, of course, only represents an intermediate degree of improvement.

The autogiros lately produced have no better performance than the equivalent conventional aeroplanes. In fact, they have a little less speed and a little less climb than the best equivalent aeroplanes. Nevertheless, they are better flying machines. If they still fall a little short of the best aeroplanes in that rather vague quality which is called " performances " they have a performance of their own, which is *utility* and *safety*.

The comparison in performance between existing autogiros of several types and best equivalent aeroplanes can be summed up as follows:—Top speed, five to ten per cent. less. Rate of climb, twenty per cent. less. Steepness of climb, fifty per cent. more. Minimum horizontal speed, fifty per cent. less. The take-off since the introduction of the deflector tail is better. The landing qualities are so well known that it is hardly necessary for me to mention them. In any case, I want to state that the present day autogiro can, with proper handling, be landed in perfectly still air with no run at all after touching the ground. In steep descent of about forty-five degrees the vertical speed of the latest machines is not more than 12 to 13 feet per second. I will deal later in this paper with the theory of the purely vertical descent, one of the more discussed performances of the autogiro.

The latest autogiros have an appearance rather different from those of 1925. They are no longer transformed aeroplanes; and fuselage, undercarriage and tail have been gradually transformed to suit better the necessities of the new system (Figs. 1 and 2). The undercarriage is wider, the fuselage shorter and the tail is of a peculiar design. Also the ailerons, which in 1925 were fixed on a transverse beam or stick, are now supported by small fixed wings, such as the bottom plane of a sesquiplane.

The rotary wings are of a different shape and construction. Their main characteristics are the smoothness of the skin, the local strength of the same to prevent deformation under very high unitary loads and the considerable flexibility of the whole blade in a plane perpendicular to that of rotation.

The blades are hinged to a central hub as in the old machines, so as to allow free flapping in flight. A secondary hinge perpendicular to the first is also provided, allowing a certain freedom between two consecutive blades. Those two articulations give, by the way, the maximum degree of freedom that rotary wings can have without becoming unstable with relation to the axis of rotation in horizontal motion.

In these machines the tail acts as self-starter to the rotary blades prior to take-off. The slipstream of the propeller is deflected upwards and the rotary blades are forced in turn to a flapping movement which is transformed by aerodynamical reaction into circular motion. Sixty to seventy per cent. of the flying revolutions are obtained in no wind by this means and take-off is possible as soon as the horizontal speed corresponding to the position of the machine on the ground is attained.

The aerodynamics of the autogiro is one of the most complex problems that can be imagined. A considerable number of parameters, both mechanical and aerodynamical, make it really awkward to handle from a purely theoretical point

of view. On the other hand, the scale effect being astonishingly great, wind channel experiments are of little use to check any approximate theory. Together with this the extraordinary sensitiveness of the autogiro to changes in certain parameters, such as pitch and profile drag explains that both eminent mathematicians and experimenters have conservatively fixed the best lift-on-drag ratio of the autogiro somewhere near seven (in some wind channel experiments it was only three point five), its maximum lift coefficient around point five and its maximum thrust coefficient at about point seven, referred to the disc area.

I must say that some of the machines I produced in the course of the experimental development were not much better than what could be expected from those conclusions. I took more than one false step. My engineering theories,

FIG. 1.

all based on energy equations since 1924 and very similar in general lines to that developed later by Mr. C. N. H. Lock, and published by the Air Ministry in the R. & M. 1127, in 1927 were not a useful guide to me until, in 1928, I succeeded in finding an analytical method of integrating the frictional losses of energy, when the aerofoil used is the Göttingen 429, which gives the average profile drag in any conditions and for any value of the parameters defining a rotor. The theory completed in this manner has allowed me to produce autogiros with the correct proportions and I can safely say that the present results check with amazing accuracy the simple assumptions which form the basis of my theory.

Simultaneously with this, I must mention the introduction of the small fixed wings in combination with the pure autogiro. Apart from being very useful constructive elements, as supports of the undercarriage and ailerons, they can improve the aerodynamical efficiency considerably and, by a judicious setting of their relative angle of attack, they can contribute towards regularising the speed of rotation of the rotor. From the efficiency point of view their action is double, because they not only give less drag per unit of the lift but, by relieving the

rotor of part of the load, they bring it nearer the optimum incidence, which is very small.

The experimental results in several countries with machines of different types permit of my stating definitely that I have obtained in practice a lift-on-drag ratio of about twelve for rotors combined with small fixed wings, the ratio for the rotor alone being about ten. As for the lift and thrust coefficients, though their accurate estimation is somewhat difficult, the figures *one* for the first and *two* for the second, referred to disc area, seem to be reliable. All this for rotors of about point one solidity.

In comparing the autogiro with the aeroplane, the fact that the former has an inferior lift-on-drag ratio is often put forward as proof of its inefficiency.

FIG. 2.

In reality what happens is that the aeroplane and the autogiro are respectively most efficient under different conditions. The aeroplane or, at least, an aeroplane of normal proportions, has a maximum efficiency in its middle range of speed, while the autogiro is at its best at both ends.

It is perfectly possible for an autogiro to be faster than an equivalent aeroplane, though its optimum lift-on-drag ratio would be inferior. Fig. 3 shows the relative shapes of the required horse-power curves in function of the speed for two normal equivalent machines, one aeroplane and the other autogiro. It will be only a question of the available horse-power whether the autogiro will be faster or not.

It can be shown that if the diameter of the autogiro equals the span of the aeroplane, and both machines have the same parasite drag, the induced and parasite power would be the same in either case, and the required horse-power equations would differ only in the term corresponding to profile drag. In the aeroplane these terms will be practically proportional to the cube of the speed, while in the autogiro it would only be directly proportional to the speed within

wide limits. This proves that the greater the speed the less the difference between both and eventually the autogiro must become faster.

The same Fig. 3 explains qualitatively why the aeroplane, in general, will have better rate of climb, since it corresponds to the range of speed for which its efficiency is a maximum, and why, on the contrary, the steepness of the climb of the autogiro can be much better than that of the aeroplane, provided only the propeller's efficiency does not drop to too low a figure at very slow speeds, which seems to show that geared propellers are proportionally of greater interest to the autogiro than to the aeroplane.

The shape of the required horse-power curves of Fig. 3 shows also the much greater changes in the top speed of the autogiro with the available horse-power than those corresponding to the equivalent aeroplane. I have had recently the opportunity of checking this conclusion in the most amazing manner, obtaining from the same machine within the same twenty-four hours a top speed increased by nearly thirty miles per hour by simply changing the propeller.

This sensitiveness to changes in parameters seems to be a fundamental characteristic of the autogiro. The third term in the equation of required horse-power, of which I have made mention before, is, for the aeroplane, proportional to the surface of its wings, the density, a coefficient which only changes slowly with the speed and the cube of the speed, while for the autogiro it is independent of the surface and the density and is directly proportional to a coefficient which changes slowly with the speed to the total weight of the machine and the speed. The other two terms being equal, it follows that the required horse-power will increase or decrease with the weight more quickly in a given autogiro than in the equivalent aeroplane of the same span, and the same applies to the density and, consequently, with the altitude, assuming the same speed in both.

This fundamental difference with the aeroplane would be against the efficiency of the autogiro but for two reasons, one aerodynamical and the other constructional. The first is that the above mentioned third term of the power equation is, in the autogiro, independent of the surface (or rather, almost independent) and the second is that an increase in diameter of an autogiro represents much less increase in weight than the same increase in the span of an aeroplane. It sounds paradoxical, but if the blades of an autogiro are substituted for others of exactly the same construction and the same chord, but of greater length, the stresses, both on the hinges and on the blades themselves will be about the same if the blades are sufficiently flexible in the plane of flapping, so that the secondary bending moments are considerably relieved by the deformation of the blade in elevation. Incidentally, that flexibility also considerably relieves any sudden overload making the autogiro the stronger the flimsier it looks.

All this makes comparison between aeroplane and autogiro unfair, assuming the same span for both, since span, that precious parameter, costs much less in the second, and this consideration corrects for the autogiro in practice the greater sensitiveness to the weight and altitude. Autogiros with correct proportions can carry the same normal load as equivalent aeroplanes and have about the same ceiling.

A definite advantage of the autogiro with regard to the aeroplane is its extraordinary aerodynamical flexibility and adaptability. In an aeroplane the load per square foot of wing area defines its landing qualities, and if the power is increased, in order to obtain the full benefit, an increase in wing loading must follow with a corresponding increase in the landing speed. Roughly speaking, the landing speed of an aeroplane is proportional to its top speed. In an autogiro the landing qualities depend almost exclusively on the load per square foot of disc area, while in order to obtain the best possible efficiency at top speed it is only necessary to keep the ratio *tip* speed to *top* speed equal to about one point five, which ratio depends only on actual blade area, assuming the pitch constant. This means that, within wide limits, autogiros can be designed to

have very different top speeds, but exactly the same qualities in landing and descent. Of course, a limit must come when the blades, even reduced to three in number (two blades only have been tested in flight and found impossibly rough) will become too narrow and thin, but beyond that limit a decrease in pitch angle can still be used to increase the rotational speed with only a slight decrease in efficiency at slower speeds, not very important in machines with a considerable excess of power. It will probably be possible to go beyond the new limit by using for the rotary blades aerofoil sections with a less abrupt stalling than the Göttingen 429, stalling that when produced on a considerable portion of the retreating blade at low *tip speed* to *advancing speed ratios*, means a sudden drop in the efficiency. I think it is very probable that tip speed to top speed ratios of about *one* will be used in very fast autogiros in the future.

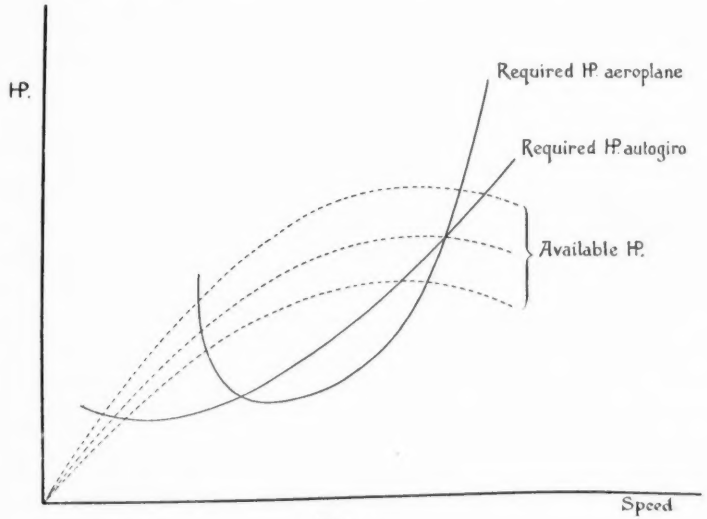


FIG. 3.

So far as we have at present ascertained and without even resorting to diminishing the pitch angle from the optimum, I am satisfied of the possibility of designing autogiros having a top speed of the order of two hundred miles per hour, and landing exactly the same as the light autogiros of the latest type.

When considering extremely fast autogiros two objections have been raised. One is that the parasite drag corresponding to the same hub, cables, etc., supporting the rotor cannot be diminished in the same proportion as the equivalent constructional elements of the aeroplane, and the other is that since the tip speed of the rotor plus the advancing speed represents the true maximum air speed of the fastest element of an autogiro, the speed of sound will be approached by that element long before any wing element of an aeroplane, with corresponding detriment to efficiency. To the first objection I will only answer that if the wonderful ingenuity displayed by the racing aeroplane constructors were applied to a racing autogiro, the parasite drag could probably be reduced to the same order as that of the external bracing of the aeroplane, especially when considering the small size of rotor to be used in such an hypothetical machine which, of course, would have a landing speed higher than the present autogiros, though certainly much slower than the racing aeroplanes. To the second I

must say that the tip speed of the propellers of the fastest aeroplanes must approach very much the speed of sound without terribly detrimental action. In the equivalent autogiros, and in virtue of what I have said before about the ratio *tip* speed to *top* speed, speeds of the order of about one half of that of sound, or some 370 miles per hour, could be attained before the speed of sound would be approached by the wing tips and even then it will only be for the tip of the blades during a few degrees of their azimuthal position. On the other hand, at those enormous speeds a drop in the efficiency of the wings, either fixed or rotary, is of relatively minor importance as their drag is very small when compared with the parasite.

In any case this only presents to me at present an academical interest and I would like it to be understood that when I have affirmed that the autogiro could attain greater speeds than the aeroplane, I only had in mind the equivalent practical aeroplane with equal weight-power ratio, without thinking of machines outside the practical range.

Very interesting considerations arise in connection with the limit in the size of autogiros.

Apart from secondary difficulties, which will probably be overcome more or less easily, the size of an autogiro seems to be limited by the diminution of the ratio centrifugal force to lift when the dimensions increase homothetically and the weight of each blade is kept proportional to the total weight of the machine. This means an increase of the coning angle and, while that increase is not very detrimental to the efficiency within certain limits, it is evident that for this and other considerations, the coning angle must be kept below a certain value. On the other hand, it is always possible to re-establish the ratio by increasing the relative weight of each blade, but this must also have a practical limit. I have arbitrarily fixed the maximum coning angle as nine degrees thirty minutes, a condition in which certain autogiros have already flown without any apparent loss of efficiency or difficulty whatever, and the maximum desirable ratio of total weight to weight of the rotor is *ten*. Considering those conditions and the others already mentioned about the *tip* speed to *top* speed ratio and suitable loading per square foot of disc area in order to keep the existing landing qualities, it is possible to write a system of inequations which show the very curious fact that the total maximum weight of autogiros complying with all of them increases very quickly with the top speed assumed for the same. A correctly calculated autogiro, with a top speed of only eighty miles per hour, should not exceed one thousand pounds all up weight, while for one hundred miles per hour the weight could be more than two thousand five hundred, and a machine weighing ten thousand pounds should be faster than one hundred and forty miles per hour.

This is only, of course, a tentative estimation, but gives, I believe, a fairly conservative idea of the possibilities. As the big machines should be proportionally faster than the small for equal power loading, because of the smaller relative parasite, which is also more favourable to the autogiro than to the aeroplane, since it is equivalent to an increase in the available power, and since the utility of big transport machines, for instance, is only real if they are fast, I can see no fundamental objections to three, four or five-ton autogiros. For bigger sizes I think it is premature to forecast anything and, in any case, I believe more for the present in small and medium size autogiros than in very big ones, which would only come in the course of time.

One of the more interesting possibilities of the autogiro is the slow vertical descent, being the first flying machine ever realised substantially capable of such a feat. The parachutal efficiency of the autogiro is one of the most interesting and apparently mysterious aerodynamical phenomena and also one of the most discussed. Certain theorists cannot see any physical possibility of the thrust on any kind of parachute being greater than that corresponding to the dynamic pressure, which is equivalent to assuming that the parachute stops completely

all the air coming directly against its surface (in the relative motion) and this leads to the conclusion that the ordinary parachute is about the optimum. A number of experiments with models, both in wind channels and in free drop, seem approximately to confirm this idea. On the contrary, other experiments such as those carried out by Costanzi and Munk gave results about twice as good in some cases.

Full-scale measures on actual autogiros in real vertical descent are difficult since, by construction, the centre of gravity of the machine is placed in front of the axis of the rotor, so that a purely vertical descent can only be obtained during a short period, which depends of course on the position of the centre of gravity and the longitudinal moment of inertia of the machine. But in every case the more or less approximate measures which have been taken, not only by myself and my co-operators, but by independent entities, have shown results which were much better than those mentioned. On one occasion an autogiro, falling freely from eighty feet and touching the ground with an angle of incidence of eighty-seven degrees in no wind at all, had a speed of impact, cinematographically recorded, of sixteen feet per second only. The load per square foot of disc area was about two pounds.

Figures from thirteen to fifteen feet per second have been obtained now and again in free descent from high altitudes for descents at large angles approaching ninety degrees on many occasions.

The discrepancy between the full-scale results and the models can be explained by the fact that the energy lost in friction through stalling of the inner part of the blades is a maximum in vertical descent. The speed of rotation (if the autogiro is considered alone, without fixed wings at all) is a minimum in vertical descent and this presupposes a maximum average angle of incidence, which means a larger part of the blades beyond stalling angle. This point is strengthened if it is considered that the models giving the worst results to my knowledge are those in which the aerofoil section used for the blades was a symmetrical one, with an extreme sensibility to changes in scale.

A careful consideration of the autogiro in vertical descent in the light of the vortex theory gives a satisfactory physical explanation of how it can actuate on a much greater mass of air per second than that corresponding to its surface and the speed of descent.

The wake of such a machine will be formed of helicoidal vortices such as those schematically represented in Fig. 4 with a circulation as shown by the arrows. At a considerable distance above the descending machine, the axis of those vortices will form a cylinder with a certain constant radius, because of the symmetry of the reactions of the helicoidal vortices on themselves, but it is obvious that near the autogiro that symmetry is destroyed and the radius of the helicoids tends to increase, widening gradually until reaching an asymptotic value, R_∞, greater than the radius of the autogiro considered.

This phenomenon of course is not new and it corresponds to the contraction of the wake of a propeller for the opposite reason, but its effects on the autogiro are much more important, since, assuming equal vortex strength, the widening of the same in the autogiro will be much greater than the contraction in the propeller, because the speed of vertical displacement of the helicoidal vortices with relation to the machine is obviously much smaller, while the *widening contracting* speed will be of the same order.

An accurate calculation of the wake deformation involves differential equations of considerable difficulty, which I have not yet been able to solve in their entirety. But by certain simplifications, which ought not to alter the order of magnitude of the results, I have reached some provisional conclusions, which are extremely interesting. The widening of the wake is, in a measure, proportional to the parachutal efficiency itself, which means a great sensibility to anything that might alter that efficiency. This is confirmed by the experimental

discrepancies I have mentioned. The law of widening from my approximate theory, which law is more or less that shown in Fig. 4, of logarithmic structure coincides almost exactly, when applied to a model tested at Farnborough (results published in the R. & M. 1116) with the position of a number of coils of smoke photographically recorded. In that case the helicoids had increased thirty per cent. in diameter one radius behind the model and should reach *ad infinitum* a diameter about fifty per cent. greater than the initial.

As to the maximum possible widening in the optimum case it is doubtful whether the simplified assumptions I have made are applicable to this condition, but it looks probable that it would be theoretically possible to reach a radius *ad infinitum* several times greater than that of the autogiro.

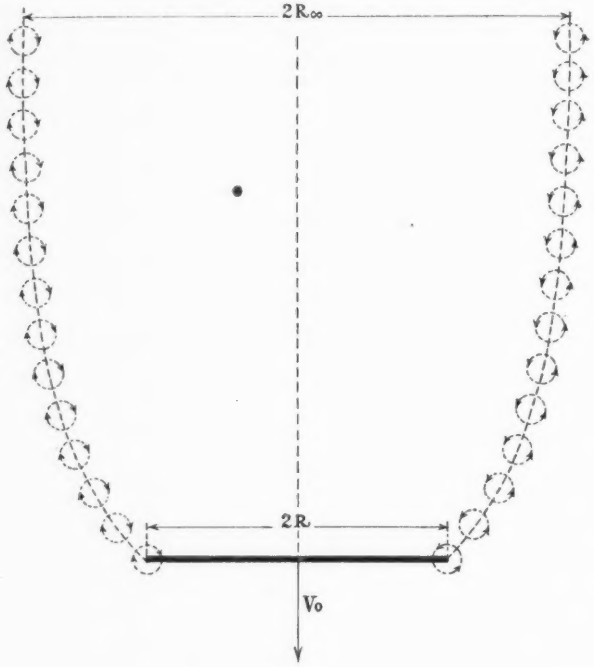


FIG. 4.

The optimum parachutal efficiency of a theoretical autogiro should be, by the indications I have, about *six* times greater than that of the ordinary parachute and the existing full-size machines appear to have fifty per cent. of the optimum, being three times more efficient than the parachute.

Recent experiments made with an autogiro having a better power ratio than any of the previous machines, and fitted with a geared propeller giving a reasonable efficiency at slow speeds, have confirmed fully my ideas as to the possibilities of the autogiro on the slow side of the speed and I think I can say that from a practical point of view a helicopter can be realised at once by simply decreasing the power loading of the present-day autogiros. In this paper I have insisted very much on the sensitiveness of the autogiro to changes in parameters. By increasing the power or decreasing the load amazing results are obtained. If a

practical helicopter of any of the proposed types is ever going to be realised, it is obvious that it will only be at the expense of weight, cost and complications without end.

In any case none has yet been realised. But if the obtaining of such a machine were worth the sacrifice of cost and simplicity (and I believe for many applications it would be justified) an over-powered autogiro, in which only load would be sacrificed, could practically do everything the helicopter is supposed to do. Take off in ten to twenty yards, forty to fifty degrees steepness of climb, eighteen miles an hour minimum horizontal speed or ten miles an hour when losing altitude at seven or eight feet per second, in addition to the vertical descent and dead stop landing qualities, would constitute performances which, while not strictly those of the theoretical helicopter, could yet be obtained immediately and would, in practice, open for such a machine all the possibilities of a helicopter. To my mind, the autogiro could be classified in two categories: The autogiro-aeroplanes, with performances comparable with those of the ordinary aeroplanes in speed and climb and relatively low powered, and the autogiro-helicopters. There is, of course, no definite point of division between both.

Before ending this paper, I must say once more that the autogiro is still susceptible to considerable development and improvement. At the same time it is already a thoroughly practical machine, and in the very near future it will be, I hope, a still better one.

The secondary development stage has now arrived where the co-operation of aircraft constructors generally can be justifiably asked and the scope of the work broadened by the participation in it of the aircraft industry whose constructional knowledge and genius have not hitherto been available.

I want to take advantage of this meeting to thank publicly all who have helped the development of the autogiro in this country, where I have carried out most of my work for the past four years. To my friends and collaborators, to the Air Ministry, to the Royal Aeronautical Society and even to my critics, I feel I am very much in debt.

Discussion

The Chairman: He thought they would agree that the lecturer had put forward a frank and moderately clear account of the present position, and a series of reasonable claims for future research leading to the production of what he termed the smaller size autogiro. Since these developments were commenced four-and-a-half years ago, under the control of the Director of Scientific Research—who would open the discussion—the slotted wing had become more or less a standard fitment on ordinary aircraft. Therefore, the advantage that the autogiro offered at the time that it was first taken up in England had to some extent been modified, in that it did not, to the slotted wing machine, offer the same degree of extra safety that it offered to a machine not fitted with the slots. He absolutely agreed with Senor de la Cierva when he said that his machine, with a suitable power weight ratio, could do in a practical manner all that it was claimed the helicopter could do.

They all admitted that safety was one of the most important considerations; but how much safer was the autogiro than the slotted wing aeroplane? They wanted to know not only at what cost, from the performance point of view, would he give that added safety; but also to consider the general convenience of operation of that type of machine. He (the Chairman) had been fortunate enough to be flying one of these later models on several occasions, and he had been amazed at the performance of the machine in the air. Being accustomed to flying an ordinary machine, he had not flown Senor de la Cierva's yet a sufficient number of hours to convince himself definitely when in the air that he had entire confidence in its performance, which, when he was on the ground, he

knew that he possessed. When one arrived over the aerodrome, say at 1,000 feet, and one found merely by casually shutting off the engine that the machine would ultimately arrive on the ground without doing anything else at all, it did take one a little time, if one were accustomed to flying the ordinary machine, to get used to sitting perfectly still and admiring the surrounding scenery. But that was undoubtedly what happened. The ground simply came up in a gentle fashion, as the machine approached it at somewhere round 15 ft. per second, which the under-carriage was capable of coping with.

He thought they might have some remarks from Flight Lieutenant Cotton, who was responsible for the use and development of aircraft for seal spotting and the like, where taking-off and landing in a dead beat fashion were extremely important.

The Director of Civil Aviation—who could not be present as he was on his way to Athens in connection with certain arrangements for Imperial Airways to fly through Greece and other countries—had sent a written communication in which he said he was still a convinced user of the autogiro, and felt that they were on the brink of making a real practical use of that type of machine. He said that even in its present state of development, it was an interesting and comfortable machine to fly. Throughout his aviation career, he had been celebrated for making extremely bad landings; and one could imagine the joy of being able to pancake from about 30 feet with impunity, and then being told by the pilot in charge that that was the right way to handle that machine. He felt that their efforts should be specially devoted towards improving the take-off. Some time ago Senor de la Cierva had promised him that he would produce a four-seater machine which would take-off comfortably from the Horse Guards Parade. The rate of climb was less than that of the aeroplane; but the climb was at a much steeper angle and the forward speed much slower, a fact which some people were apt to forget. Thus, in its present state of development, one could say its ability to get out of an enclosed area was distinctly better than that of the average aeroplane. He strongly recommended the fitting of a geared propeller to an autogiro as soon as possible.

He (the Chairman) would like to ask Senor de la Cierva what was his idea, in the future development of the machine, as to means for speeding up the rotor preparatory to taking-off. They all knew what the old arrangements were. But under the present arrangements he has shown that it was possible to spin the rotor up to 120 revolutions per minute and it seemed to work very well indeed. There were two other schemes. One was driving the rotor round by coupling it to the engine by a suitable clutch, and also by a method of jet propulsion, perhaps he would tell them about these in the discussion.

The Director of Scientific Research had kindly agreed to open the discussion, and he (the Chairman) would remind those who were not there four-and-a-half years ago that the fact that they had the autogiro in its present state, and that these developments were being carried out by Senor de la Cierva in England, were due to the initiative and energy put into the problem in the very early days and since by the present Director of Scientific Research.

Mr. Wimperis (Director of Scientific Research): He had listened with the greatest pleasure to the lecturer, and he thanked him on their behalf for coming and for giving so interesting and full, though not as full as he would have liked, account of what he had been doing in the last five years. They had all of them become so used to the autogiro, that it was a little difficult to carry their minds back to where they were nearly five years ago. He remembered so well the first demonstration of the machine in flight at Farnborough. He remembered the look of amazed incredulity on the face of the late Chief of the Air Staff when the machine really flew, because he had scarcely believed that it would fly. It was a great tribute to Senor de la Cierva's energy and ingenuity as an engineer

that he had produced the rotary wing machine that had been proved to be capable of carrying out a cross-country journey worth talking about. During the years which had passed, the Air Ministry had built several of these machines, of slightly different types, with a view to ascertaining whether the predicted performance of the machine, based upon model tests made in the wind tunnels at Teddington and the calculations made by the staff there and at Farnborough, would in fact actually be borne out. He did not know that they were yet quite in a position to assess the efficiency attainable by these aircraft, because there were lots of little items in the design which had never been used before and which tended to go wrong; so that the investigation could not be carried out at the speed which one would like. But speaking generally, he would say their results had confirmed the figures given by Senor de la Cierva at the beginning of his paper, where he spoke of the loss of top speed and rate of climb as compared with the conventional aeroplane. How far were those two losses of top speed and rate of climb, and one might add miles per gallon, serious? For certain purposes they were very serious indeed; but one could not expect advantages without paying for them in some way. The enormous advantage of landing with almost no horizontal run at all, a run rarely exceeding the wheel base of the machine, was so great an advantage for quite a number of purposes, particularly private flying, that it should, he submitted, outweigh the disadvantages of the fuel costing a little more, and the top speed being not quite so high. For landing under conditions of fog, there was nothing to rival it in any heavier-than-air machine. It was not impracticable, with radio beacons, to find an aerodrome under any conditions of fog; but to land on the aerodrome when one had found it was quite another story; unless the story was that told by their lecturer that night, which was, as the Chairman had said, that one "pulled the stick back and sat down." The Chairman had spoken about the long run when taking-off which was necessary, so he would not say very much about that, except to say that they had done their best at the Air Ministry to assist Senor de la Cierva in the development of various self-starting devices. The "scorpion tail," the turned-up tail, which was the most promising of them, was a sound idea. It would succeed, he hoped, in reducing the length of the run to something that they were accustomed to with normal types of aircraft. Without some such device the considerable amount of taxying round the aerodrome necessary to get up speed was a great trial to the under-carriage, unless the aerodrome was an unusually perfect one; and there were some which were not by any means perfect.

From time to time he had had the following kind of representation made to him at the Air Ministry. In what Senor de la Cierva was claiming to introduce, was he claiming anything more than could be done with an ordinary type of machine, if one only had enough slots in it? When he read of the Guggenheim competition, and saw that a Handley Page machine, supplied with slots, was being entered, and that two of Senor de la Cierva's machines were being entered too, he thought that would produce an extraordinarily interesting opportunity of seeing whether that statement which had so often been made to him really had anything in it. He was sorry that the comparison never took place as the two autogiros were withdrawn from the competition. He had not seen any public statement as to why they were withdrawn; and perhaps the lecturer would tell them about that to-night.

The work of investigating the properties of this machine was continuing, and they had faith in its future. They believed there were certain purposes which it could serve in a way that no other machine that they knew of could serve. His personal view was that the biggest opportunity would lie in providing a light machine for private fliers in places where aerodromes were not abundant, or where the country was broken up by rivers and transport was, generally

speaking, difficult. In such conditions he would have said that that type of machine would have invaluable advantages.

Mr. McKinnon Wood: The paper struck him as being principally a statement of his faith in his machine. He hoped the lecturer would forgive him stating that he had a little difficulty in taking quite such an optimistic view about the future of its performance; but then he confessed that Senor de la Cierva knew very much more about autogiros than he did, as, in fact, he felt a little out of date. He had only personal knowledge of the performances of one autogiro designed about 1925. That was a machine with which they had been experimenting, which had a speed range of something like 40 to 70 miles an hour and a " service ceiling " very near sea level. Progress had been considerable since that date. That was a two-seater aeroplane of 200 horse-power, and a much better performance was put up to-day by a two-seater aeroplane with only half that horse-power. He regretted that he had not a more intimate knowledge of the autogiro of to-day; but he hoped that the writer of the paper would give them some actual figures of performance of autogiros in the matter of power, weight, speed and climb.

Mr. Wimperis had referred to the Guggenheim competition. He, too, had hoped that something interesting in relation to the autogiro would have come out of that competition; because, if one took the diagram in the paper, Fig. 3, it appeared that the autogiro should be a good machine for the big speed range which was one of the things the competition was directed to obtaining. A good slow speed, a steep angle of descent, and a steep angle of ascent, were among the chief features of the competition. There was nothing in the rules of the competition requiring a high rate of climb, which it was generally agreed was the weakest point of the autogiro.

It was not, perhaps, a matter of great practical importance—people in general were quite content to descend at 45 degrees—but he would like to say something about the question of vertical descent. He would not undertake to prove that a parachutal coefficient of two was an impossibility, though it seemed to him highly improbable. As to the explanation given in the paper, he did not think that the spreading out of the vortices could explain a parachutal coefficient of two on the ordinary familiar theories of airscrews and windmills, because, according to the theory of Froude, if the ratio of R infinity to R in the diagram were $1\frac{1}{2}$, which was suggested in the paper as having been measured at Farnborough, the coefficient then would be of the order of four-ninths; but it would only reach a limiting value of half if that ratio were infinite, *i.e.*, if the airflow up through the autogiro were finally brought to rest, the highest value one could get would be $\frac{1}{2}$. That did not mean that nothing greater could be obtained, but that the theory was not applicable to such extreme cases. Actually the highest model coefficient measured was as quoted in the paper, 0.7 and the different observations varied from 0.6 to 0.7. The resistance of a disc, from Eiffel's experiments, was 0.55; from Miss Bradfield's experiments the resistance of a hemispherical cup was 0.75. The autogiro coefficient was between the two. He found it hard to believe that it could be much greater even if the air flowed to some extent through the plane of the autogiro from above to underneath; and it appeared that most of the flow must be upwards through the disc. A fair amount of flow was necessary in order to keep the autogiro rotating.

Major Mayo (Technical Adviser to Imperial Airways): It certainly was a great disappointment that the autogiro did not turn up for the Daniel Guggenheim Safe Aircraft Competition.

He believed that one of the difficulties that had been experienced in regard to the competition, was in connection with the flattest angle of glide. That was rather a severe condition for the autogiro and he knew that throughout the competition Senor de la Cierva had criticised that particular condition, because

he claimed that the great advantages of the autogiro in its steep descent far outweighed the advantages of a flat glide from the safety point of view. He quite agreed that the steep glide was more important, but thought that any aircraft ought to be able to glide for a reasonable distance in case of engine failure. He would be extremely interested if the lecturer could give them some information as to whether he had been able to achieve a flat glide which was comparable with that of an ordinary aircraft.

Mr. WALKER (Chief Designer, De Havilland Aircraft Co.): There was one point in connection with Fig. 3 which had been shown on the screen in which it was shown that the autogiro had a higher top speed than the aeroplane, if one had sufficient horse-power. There was a difficulty in saying what was the "equivalent autogiro," and everyone would probably have some rather different ideas on that point. If one assumed that an autogiro having the same span as an aeroplane was an equivalent machine, it was then very difficult to see how it could be faster at the higher end of the speed scale. The ordinary resistances on which the speed depended were all of them the same in both machines, except the wings of the aeroplane and the rotor of the autogiro. In the case of the wings, it was clear that the horse-power required depended on the cube of the speed. As any differences in induced drag could be neglected under speed conditions, one would imagine that the profile drag must be greater for the rotor, because it would depend on the mean square of the speed of the blades, which would be greater than the squared mean speed and therefore greater than that of the aeroplane wing. That was one of the points which struck him after looking at that figure. He would also like to ask Senor de la Cierva if he thought there was any chance of flutter on the rotor at high speeds. It did not seem impossible, although they were hinged at the root; but possibly he had some experience of what might happen at high speed in that respect.

Major GREEN: The paper was on general lines and the author, therefore, was fully justified in dealing with it in the most general way possible. At the same time too, to people who were not so intimately acquainted with the problem as he was, it was rather hard to follow these general arguments and assumptions. It would add immensely to the value of the paper if the author would add some concrete instances, giving what the actual speeds were, and weights and so forth. A diagram like Fig. 3 meant very little when there was no scale to it. The other thing which had struck him as remarkable was the great increase of speed with a change from one airscrew to another. That was almost incredible; and it would be very valuable if one could have some more particulars of tests, and some explanation of why there were these extraordinary figures of speed.

Dr. HELE-SHAW: About 20 years ago Senor de la Cierva began his practical experiments in aviation. Four and a half years ago he read his paper for their Society in that hall, amidst a chorus of well-deserved congratulation, but as far as he remembered, no one congratulated Senor de la Cierva on the most remarkable thing of all, namely, his immunity from a fatal or even serious accident. In that paper, he wrote: "In 1918 I had constructed a large biplane with three engines, which, after a most satisfactory trial flight, was wrecked precisely by losing flying speed. The accident diverted all my energies to the solution of the problem of eliminating this danger; for the possibility of losing flying speed and the uncertainty of landing are in fact the only faults with which we can reproach the aeroplane, otherwise it is practically perfect in point of speed and manœuvrability." That night the author of that paper stood before them sound in wind and limb, after conducting experiments himself with 30 or 40 different machines. This meant that he had achieved the object with which he had set out. Like the author, he was an inventor; and if having an object in view one attained the object, which in this case was "safe landing," then he

could claim success. To-night the Director of Research told them what he for one was delighted to hear, that for landing in fog, landing without any advancing movement of the aeroplane, they now had a safe machine. Forty years ago he was a Professor of Engineering at Liverpool, and the Mayor, who was a personal friend, sent for him and asked him not to lecture on aviation, because people were beginning to say a man was totally unfit to be a Professor of Engineering if he was talking about such absurd things as flying.

He for one did not feel inclined to obscure the main point of the author's work, namely, safe landing, by throwing doubt on further successes which seemed to be expected from his invention. The object which he had set out to attain was safe descent, and about 18 months ago, at the Hampshire Pageant, he saw one of the Senor's machines. True, it broke a spring on one side, but it descended vertically in the middle of the ground without danger to the passengers.

That night the author came before them to give them various other comparisons with aeroplanes as follows:—Rate of climb less, top speed less, steepness of climb 50 per cent. more, and minimum horizontal speed 50 per cent. less. When he, the speaker, came down to the ground, he wanted to come down with that smaller horizontal speed.

He admired one device of the author, namely, the blades being hinged to a central hub as in the old machines, so as to allow free flapping in flight, and a secondary hinge perpendicular to the first which was provided to allow a certain freedom between two consecutive blades; "those two articulations giving the maximum degree of freedom that rotary wings can have without becoming unstable with relation to the axis of rotation in horizontal motion." Another point which interested him very much and to which the Director of Research had also referred, was that in the new machines the tail acts as self-starter to the rotary blades prior to taking-off. The slipstream of the propeller is deflected upwards and the rotary blades are forced in turn to a flapping movement, which is transformed by aerodynamical reaction into a circular motion. Sixty to 70 per cent. of the flying revolutions are obtained in no wind by this means, so that take-off is possible as soon as the horizontal speed corresponding to the position of the machine on the ground is attained.

He, therefore, thought they were justified in congratulating the inventor not only upon his immunity from accident, but on having added further beautiful devices to the invention. He remembered four and a half years ago the astonishment of the world at the fact that that horizontal wing would start into action. He believed the inventor did not know sometimes which way it would start. He thought the final words with which the author concluded his paper justified everything he had done, namely: "The secondary development stage has now arrived, where the co-operation of aircraft constructors generally can be justifiably asked." In other words, the co-operation of the practical men was invited. As an inventor he could say that if any invention reached that secondary stage the invention was sound in principle. If it were not sound it would never reach that secondary stage—it would be dead before it got there.

Mr. Pye (Assistant Director of Scientific Research): He must confess, in relation to engineering structures, to a prejudice in favour of stiffness. No doubt these marvellous rope bridges across ravines in Africa and Borneo had ample factors of safety, but personally he would prefer a steel arch to go across on. Speaking purely as a man in the street, he felt there might be others like himself who, when they saw for the first time an autogiro flapping round, felt this prejudice in favour of stiffness rise up in them. One could not help being apprehensive of large pieces of structure moving at great speeds in rather close proximity to oneself. These remarks were really addressed not so much to Senor de la Cierva as to other people in the room who had flown these machines.

It would be interesting if some of them would say whether they felt in themselves any sort of prejudice against flying in a machine of which the essential part was a large piece of moving structure. He felt that himself; and he believed that before this machine could win a place as having a real future in aviation, the inventor would have to get over that prejudice in others besides himself.

Mr. MANNING: He thought loss of top speed was important. The only excuse for the aeroplane was that its speed was greater than that of any other form of transport. That was an advantage that must be pressed. With a good many existing light aeroplanes, if the conditions were slightly unfavourable, say a 20 miles an hour head wind, it was probably difficult for the machines with passengers and luggage to fly from London to Paris without landing to obtain further supplies of petrol. The expenditure of petrol in the case of the autogiro would be worse, and it would probably be nearly impossible to do that journey without landing for a fresh supply. With regard to the gliding angle, it was clear that the danger in crossing the channel would be rather larger in the case of the autogiro than in the case of the Moth at the same height. There were two other points also which had not been investigated. It had always occurred to him that the advantages which the autogiro had over the aeroplane were important in two particular directions. One was in the case of the seaplane. It seemed to him that a machine which could be pulled off the water quite rapidly with a low forward speed would be very useful for seaplane work, especially as it was possible that the arms of the rotor might be made to fold when the machine was sitting on the water. In the case of the seaplane top speed was less important; and the speed of climb was also less important. In fact, the points on which the autogiro was admittedly inferior to the aeroplane were of very much less importance in the case of seaplanes, whereas the advantages of the autogiro come out very strongly in that connection. It had always occurred to him that in the case of night flying, which would undoubtedly have to be gone into to a much greater extent in the future, it would be much safer to fly by night with an autogiro than with an aeroplane. If one was going to crash, the autogiro crashed vertically at a comparatively low speed, whereas the aeroplane usually crashed end on; and it was that type of crash which was dangerous to life.

Captain RAWSON: He had flown about 1,500 hours in an ordinary type of machine and about 200 hours in an autogiro. After about the first ten minutes he had altogether lost any consciousness of anything buzzing round his head; and if any other pilot who had flown an autogiro were asked, he thought he would confirm that statement. The feeling that one had a number of loose wings wandering round and round wore off after about ten minutes in the air. As regards the feeling of safety, he felt safer flying across country in an autogiro than he did in an ordinary machine. He had to go up two or three times a year for his normal training. In the first half-hour, in a normal machine, he was afraid of letting it drop out of his hand, whereas in the autogiro, at an altitude of 200 feet, he did not mind anything which happened, because he could bring it down anywhere and not damage himself and probably not even the machine. As he had done most of the performance tests, perhaps he might give one or two outstanding figures. It was said that the first giro had a speed range of 40 to 70 miles an hour. The maximum speed range they had attained up to now, taking a conservative estimate, was from 25 to 112 miles an hour. That had actually been measured. A machine in England had done from 25 to 106 miles an hour, measured officially. In the King's Cup Race of 1928, flying from Hendon to Norwich, a distance of 99 miles—there was no head wind worth talking about, but there was a cross wind—99 miles was flown in an hour and five minutes, three minutes of which was taken in taxying round the aerodrome to take-off. A similar machine was built and efficiently timed by the Italian

Government over a measured distance, and the official figures were 106 miles an hour. Both those machines could fly 25 miles an hour; and also in flying at Newcastle-on-Tyne, in a demonstration, he had actually had a minus on the indicator. As regards long distance flying, the farthest flight by an autogiro has been 140 miles non-stop. That was a machine which only had petrol for an hour and 45 minutes on board.

Captain YEATMAN: He hoped that Senor de la Cierva would publish in the Journal his mathematical theory of the autogiro, which they were very anxious to hear; and also some performance figures, backed up with as much legally compelling evidence as he could obtain.

Major LOW: He thanked the lecturer for his paper and reminded him of the small collaboration he was able to give four and a half years ago. He had then tried to work out a physical theory which was divided into part 1 vertical descent and part 2 horizontal flight or flight at an angle. At the end of part 1 he found that his autogiro fell twice as fast vertically as Senor de la Cierva's observed results and gave up his attempt to formulate a physical theory, which he had not found time to renew since.

Flight Lieutenant BONHAM-CARTER: Nobody there had actually brought out the fact that they owed the invention of the autogiro entirely to a sheep. It happened in the following way. Senor de la Cierva was flying in the very early days of aviation from one end of a field to another. After a time, he thought he would go to the next field; so he took-off in his aeroplane and flew over the hedge. When he came into the next field, there was a sheep, so he pulled back his stick to avoid the sheep and the machine went up and stalled, and fell back on its tail and crashed. Senor de la Cierva had a sleepless night or two and thought of the autogiro. That was more or less what happened. After that he produced his machine. The next problem, after having found a machine that would fly, was to overcome the starting difficulty. He went through various phases of thought. One of his suggestions was to place at the end of each wing a rocket. He (the speaker) was very sorry that Senor de la Cierva did not go on with that suggestion. If the machine had appeared with rockets at the end of each wing, it would soon have become a popular attraction. At one time the usual method of starting the autogiro was to have a wire and get a number of people to pull this wire away from the machine. Senor de la Cierva discarded the wire when he found that taxying would start the giro. To-day he had got this deflector tail; perhaps the lecturer would tell them whether the deflector tail was really a solution of the problem and whether the machine would stand up to the bump which it must get each time the rotors went over the deflector tail. There must be a very big vibration owing to the fact that for a short period in each revolution of a blade there came about this violent upwards jerk. He would like to know whether there were any mechanical difficulties arising from that violent bumping. One or two people had emphasised that the great advantage of the autogiro was that it could land easily anywhere; but he did not think anybody had brought out the point that the autogiro was absolutely spin-proof. The slotted machine would spin, and would probably damage the pilot if he inadvertently stalled near the ground. But the autogiro would not spin. In difficulties, one could pull the stick back and sink. The rate of descent might be higher, but one would come down straight. That was a great advantage when landing in a very small space. Somebody asked whether pilots had any objection to flying in a machine on which there were large rotating masses. He did not think there was anything in that. One could take the machine off and feel perfectly happy straight away. There was a certain prejudice about hanging on to a single bearing; but when one got into the air, one soon got over that. One could do things with it that one could not do with any other machine. One could treat it like the normal machine in

many respects, but one could also take liberties which would be likely to cause trouble if taken with the normal aeroplane.

Sir SEFTON BRANCKER (*communicated*): He had the honour of presiding at his first lecture some four years ago and giving his proposals his full support. He was still a convinced believer in the autogiro principle and felt that they were on the brink of being able to make real practical use of it.

Even in its present state of development it is a most interesting and comfortable machine to fly. When on the ground the system by which the windmill supports the machine in the air tends to create misgivings in the mind of the would-be pilot; but the moment it gets into the air the system seems to be perfectly logical and dependable, and after a few minutes' handling the pilot experiences a feeling of complete confidence—at least that was his experience.

He felt that at present their efforts should be specially devoted towards improving the take-off. Some time ago, Mr. de la Cierva promised he would produce a four-seater machine which would take-off in any wind from the Horse Guards Parade. The rate of climb, of course, is less than that of the aeroplane; but the climb is much steeper and the forward speed much slower, a fact which many people are apt to forget. Thus, even in its present state of development they can say that its ability to get out of an enclosed area is distinctly better than that of the average aeroplane.

He would strongly recommend the fitting of a geared propeller to an autogiro as soon as possible.

He would like to ask Mr. de la Cierva one question. When flying in bad weather a heavy downward current is sometimes experienced in which an aeroplane will drop like a stone 400 or 500 feet; gravity ceases to work; the engines stop owing to the cessation of gravity feed; and the passengers and hand baggage fly up to the roof and remain suspended until the end of the bump. What would an autogiro do under such conditions?

REPLY TO DISCUSSION

Senor J. DE LA CIERVA: Sir Sefton Brancker, the Director of Civil Aviation, had sent a very kind letter, in which he asked what would be the behaviour of the autogiro on the occasion of these hair-raising bumps which sometimes happened. He was sorry that his pilot had not answered that question, because he has had some experience of that. He was flying through Germany last year in an autogiro accompanied by the Secretary of the Autogiro Company, who was undergoing his first flying experience. They were nearly thrown out of their seats by a terrific bump, the machine falling 500 feet. The wings became horizontal for a moment; but after a few seconds everything became normal and nothing happened. As a matter of fact, it might be interesting to state that the autogiro behaves in bumps better than the aeroplane, due to the flexibility of its lifting means.

The Chairman asked me what other self-starting methods than the system of the deflected tail were being contemplated. There were many possibilities of a self-starter with an autogiro. The obvious conventional solution would be a direct mechanical drive from the engine, and that solution was being tested at the present moment. There was no doubt that the problem could easily be solved by that method, if weight complications were neglected. It was merely a question of engineering progress and whether that method was practicable or not. There was another method which was derived from that more or less wild experiment which Mr. Bonham-Carter had been telling them of, of rockets on the tips of the rotor. The rockets did not seem to be a very great success in themselves, but there was the possibility of starting a rotor by means of jet reaction not applied to the ordinary flight conditions, but only for starting. Some experiments already made had been quite successful. Judging from his

personal experience, for general use the deflector was sufficient, even in its present form; and it certainly was possible to improve it greatly.

Mr. Wimperis, who was responsible for his being there, as he was responsible for his coming the first time to England, had said that he was disappointed that the autogiro did not appear in the Guggenheim Competition, and other speakers had made the same remark, and had asked him explicitly to state why the autogiro did not appear. Major Mayo's words had given the real answer—that they were not ready. Most of them were acquainted with the difficulties of aviation, and knew that aeroplanes were only fast in the air. They were not fast enough, and the 1st October came without their being ready. As to the question of flat glide, he might say that in fact an autogiro had a worse angle of glide than the ordinary aeroplane; but they thought they would have passed that test and other tests, had they been in time for the Guggenheim Competition. Several speakers had asked for definite figures of performance. Captain Rawson had mentioned some, and he would just add a few more. Autogiros of 200 horse-power engine with all round weight of about 2,500 lbs. have reached 112 miles an hour maximum horizontal speed and minimum horizontal speed of 25. The rate of climb was about 1,000 feet per minute and a steepness of climb of about 20 degrees. He said in his paper that the autogiro was not to-day as fast as the best equivalent aeroplanes; but he by no means meant to say that the autogiro would always be inferior. That was what he had tried to prove with Fig. 3. At present the autogiros were slightly inferior. If one considered that only a few years ago they were very much inferior, in view of the rate of progress made, one could see that the autogiro was catching up the aeroplane in performance. He might be wrong, but he hoped that in the near future it would be scratch with the aeroplane. Mr. Walker said he could not understand why the autogiro was said to be as fast as the aeroplane, or even faster, seeing that the unitary profile drag of the rotary wings was much greater than that of the ordinary fixed wings. That was true as to the unitary drag; but the surface of the rotary wings was much smaller than that of the fixed wings; and on the autogiro the total amount could be less even if the unitary drag was much more. For instance, an autogiro has a wing area something like a fourth of the wing area of a more or less equivalent aeroplane; so that if the unitary drag was four times more, it had the same amount of total drag.

He could say that flutter, in the sense in which it was understood in an aeroplane, had not been produced. There had been many cases of resonance between blades; and in fact he had spent most of the time since he came to England for the first time trying to cure vibration, which was absolutely cured to-day; but that vibration had nothing to do with flutter, or torsional resonance arising from a blade in its own rotation. The fact that both speed and incidence change continuously for every blade make practically impossible the maintenance of any critical resonant condition unless of what might be termed a coincidence of second degree, which is almost out of the question.

Mr. McKinnon Wood said he did not share the lecturer's faith in the future performances of the autogiro. That was a question of faith and could not be discussed; but in passing he had asked him to explain the very high parachutal efficiency of the autogiro. That was a problem not to be dealt with by pure philosophy; and it would be better if the Aeronautical Society gave him the hospitality of its paper to put it in writing, as it would be too hard to discuss then, on account of difficulty of language and lack of time. It was not reasonable to expect that phenomenon of high efficiency to be explained by the Froude theory. There was no ordinary airscrew theory which really explained it. But there is enough experimental evidence to show that the autogiro's parachutal efficiency was much higher than that of the ordinary parachute. In some tests

not made by himself, but by Constanzi, in Italy, as far back as 1909, he found a coefficient with a rotating windmill of 18 thin blades equal to 1.2 in English absolute system, which was nearly equal to twice that mentioned. Also, in some experiments made by Prof. Munk, in America, there was obtained a coefficient something higher than that which Mr. McKinnon Wood had mentioned. It was, unfortunately, very difficult to get actual figures on that point, because the autogiro had its centre of gravity in front of the axis in order to prevent a true vertical descent, so that the machine would not be any longer in control, but would be thereafter a parachute. But on many occasions, descents practically vertical have been obtained for several hundred feet and all measures, whether taken by themselves or by independent and even official persons, seem to prove that a parachutal coefficient in true scale of about two has already been attained in agreement with his theoretical results.

PROCEEDINGS

NINTH MEETING, SECOND HALF, 65TH SESSION

The Ninth Meeting of the Second Half of the 65th Session of the Royal Aeronautical Society was held in the Lecture Hall of the Royal Society of Arts, at 18, John Street, Adelphi, London, W.C.2, on Thursday, April 3rd, 1930, when a paper on "The Technical Organisation of the Compagnie Generale Aeropostale," by Monsieur P. Grimault, was read and discussed. The President (Colonel the Master of Sempill) was in the Chair.

The PRESIDENT: It was a great privilege for the Society to welcome M. Grimault, the Technical Director of the Compagnie Generale Aeropostale, which operated one of the longest air lines in the world. Emphasising the great achievements of the company, he said that at the commencement of 1928 it was running a service from Paris to Buenos Aires, the whole journey, with the exception of the South Atlantic crossing, being accomplished by air. In July, 1929, the air service was extended across the Andes to Santiago. It was necessary to climb to 15,000 feet in order to negotiate the Andes. By the summer of 1930 the company hoped to have tested flying boats, which were under construction, and to be operating experimentally the South Atlantic crossing from Dakar (French West Africa) to Natal (Brazil) by means of these flying boats. So far that crossing had been effected by ocean-going steamboats. Therefore, in a few months it was hoped to link up Paris and Santiago directly by air. At present a letter posted in Paris for Santiago reaches its destination in 8½ days by air mail, whereas the journey by other means of transport occupied 25 days.

The President also expressed indebtedness to M. Grimault for having travelled from Paris to London specially to be present at the meeting.

In a brief outline of M. Grimault's career, he said that before the Great War he was an officer in the French Artillery; during the war he had served as an air pilot and an observer, had become a Squadron Leader, and subsequently had been promoted to the equivalent of a Group Captain. From 1918 to 1927 he had been the head of the Aircraft Section of the Service Technique Aeronautique, and in 1927 was appointed a Director of the Compagnie Generale Aeropostale, which appointment he continued to hold.

THE TECHNICAL ORGANISATION OF THE COMPAGNIE GENERALE AEROPOSTALE*

BY

P. GRIMAULT

Summary of the Service

The ground covered by the Compagnie Generale Aeropostale comprises the following:—

1. The main air line from France to Chile via Toulouse, Casablanca, Saint Louis, Natal, Rio de Janeiro, Buenos Aires, Santiago.
2. The tributary lines: Bordeaux-Toulouse; Marseilles-Barcelona; Buenos Aires-Asuncion; Buenos Aires-Commodore-Rivadavia.
3. The line Marseilles-Algiers.
4. The line Paris-Biarritz-Madrid.

* Translated.

Flying on this last route is suspended during the winter and renewed in May.

The following table gives the distances covered on the main route:—

Toulouse-Casablanca	1,845 km.
Casablanca-Dakar	2,850 ,,
Dakar-Natal	3,200 ,,
Natal-Santiago	5,850 ,,
Total	13,745 km.

The subsidiary distances are:—

Bordeaux-Toulouse	215 km.
Marseilles-Barcelona	495 ,,
Buenos Aires-Asuncion	1,100 ,,
Bueno-Commodore-Rivadavia	970 ,,
Total	2,780 km.

And for the following lines:—

Marseilles-Algiers	800 km.
Paris-Madrid	1,200 ,,

The total network of lines actually developed by the Company is 18,325 km., and it is entirely operated by aeroplanes or seaplanes, except for 3,200 km. on the South Atlantic portion of the route. Each part of the route has its own special difficulties.

The journey from Toulouse to Casablanca involves crossing the Pyrenees through the Perthus pass at a height of 1,000 m. The summits of the Pyrenees are often covered with snow and hidden by mist, which provide the first serious obstacle on the main route, so that aircraft have to fly high.

Afterwards the line follows the Spanish coast where the Sierra comes down to the sea. The rocky coastline offers no facilities for a forced landing, and the making of landing grounds is not easy.

From Tangiers to Casablanca the chief trouble is due to the frequent mists on the west coast of Africa.

The journey from Toulouse to Casablanca is made daily each way, and is available for passenger traffic.

From Casablanca to Dakar the route follows the coast and covers for a large part of the journey from Agadir to Port-Etienne desert country where the Spanish posts of Villa Cisneros and Cape Juby are the only landing places where fresh supplies can be obtained. Outside these posts the desert is infested by hostile tribes who hold to ransom anyone who falls into their hands.

Flying conditions are often not very good. The high temperature makes it necessary to take particular care over the fuel supply and cooling of the engines.

Mist or haze is very prevalent on all the coasts. Sand storms are frequent and are a source of considerable trouble and are the cause of wear and tear of the engine through the particles of sand sucked in.

The problem of crossing the Atlantic has not, up to the present time, been solved commercially, and will be considered later.

The route from Natal to Buenos Aires follows the South American coast line. In places the forests come down to the seashore, whilst in others the coast is rocky. Moreover in that tropical climate the formation of thick clouds is accompanied by heavy torrential rains, which restrict visibility and make flying difficult.

An enormous amount of work has been found necessary to clear the luxuriant tropical growths in order to prepare landing grounds in the forests and involves daily attention to keep them clear.

Between Buenos Aires and Santiago, or more exactly between Mendoza and Santiago is the formidable barrier of the Andes. Many of the passes of 4000 m. in height. The Pacific gales cause such violent descending currents that it is necessary to fly at least 5000 m. to cross the Andes.

The journey from Casablanca to Santiago is only flown once a week in each direction.

The Organisation of the Routes

The landing grounds have been fixed from the beginning taking into account the commercial and postal necessities, and of the material one had at one's disposal.

At the beginning Salmson aircraft were used, but since 1927 Breguet 14 is specially fitted and used. This allows a longer maximum stage of 600 km. Actually it would be possible to make still longer stages and a certain number of primitive landing grounds, in particular on the journey between Casablanca and Dakar serve for emergency landings, enable the length of the intervening flights to be extended to 1000 km.

The compulsory landing grounds are Barcelona in Spain, Tangiers, Rabat, Casablanca, Agadir in Morocco, Pernambuco, Bahia, Rio de Janeiro and Montevideo in South America.

The method of working is as follows:—each aerodrome has one or two aircraft in reserve. When an aircraft lands one of the reserve aeroplanes is ready to take off and passengers and freight are transferred.

This method of working has been adopted since it reduces to a minimum the time spent at the aerodrome. By this method the aircraft used in turn reach the headquarters at Toulouse and Buenos Aires. Thus each aerodrome always has its proper quota of aircraft which, however, is constantly changing. All aircraft have equal service and are maintained and overhauled as regularly as required at those aerodromes where there is the necessary technical organisation.

As I have already indicated the workshops and chief supply depots are at Toulouse and Buenos Aires.

At Toulouse major repairs and overhauls are carried out under the supervision of the Société Industrielle d'Aviation Latécoère.

At Buenos Aires the workshops belong to the Compagnie Generale Aeropostale and there complete overhauls can be carried out of engines and aircraft, as well as the construction of the chief parts of aircraft. There are small workshops at Casablanca, Rio de Janeiro and Marseilles.

The fitting up of the aerodromes does not call for any particular comment. They are all equipped for night arrival and departures. The red ground beacons are placed 30 cm. above the ground and all obstacles have similar beacons fixed on them. The lighting of the aerodrome is by means of mobile searchlights, most of the Brandt and Fouilleret type.

Each aerodrome has a lighthouse beacon. These beacons are provided with 3,000 watt lamps, and under normal conditions can be seen at a distance of 100 km. They are each lettered on the top by a small flashing light to indicate the name of the aerodrome to the pilot. The full organisation for the routes for night flying requires beacons between the aerodromes, and these beacons are now in the course of construction. The actual parts of the route now equipped are those from Bordeaux-Toulouse, Perthus and Tangier and Casablanca. The ground from Barcelona to Perthus should be ready very shortly.

Wireless Organisation

The wireless service of the Company is, I believe, the most efficient private wireless service in existence. The service is aimed to provide the following :—

1. To enable constant communication between the various aerodromes—
   (*a*) To allow the management to communicate without delay to every point (network of management).
   (*b*) To give regular communication to ensure the proper supply of material and personnel (network of service).
   (*c*) To ensure that all meteorological information necessary for safe flying can be obtained and that communication between aerodromes for that purpose can be carried out (network of safe flying).

2. To enable pilots to keep in touch with aerodromes, and ultimately, with one another (wireless air network).

3. To enable aircraft to be navigated by directional wireless.

4. To allow the dispatch and relief boats of the Company on one part, with the ground organisation on the other part, to keep in touch with the seaplanes in flight.

The means for attaining these different ends are as follows:—

1. On the ground.

Each aerodrome has a wireless station comprising:—

(*a*) A transmitter to send out short-waves (15 m. to 60 m.) and long-waves (400-2,000 m.).
The power for these wireless transmitters varies according to the aerodrome from 100 watts to 1 kw. on the aerial.

(*b*) A receiver to enable an operator to listen in on wave-lengths from 15 m. to 3,000 m. and to receive directional wireless signals from 200-3,000 m.

To this receiving apparatus are added two receivers of small range for emergency help calls (one for short and one for long-waves). By this means several people can listen in at the same time at each aerodrome.

Generally the managing control is enabled by short-wave transmission and reception to keep in direct touch with the following places where there is wireless apparatus of at least 500 watts in the aerial.

Paris-Toulouse-Casablanca (in preparation), St. Louis, Porto-Praia-Natal-Rio de Janeiro-Buenos Aires-Santiago-Asuncion-Bahia-Blanca-Commodore-Rivadavia.

This network works in with those for supply and navigation through Casablanca-Toulouse and Marseilles.

The liaisons between the intermediate commands are on short-wave wireless (100-200 watts power).

The stations of the chief network enable direct communication between any two stations. In this way Paris and Toulouse communicate direct with Buenos Aires and Rio. Practically, however, messages for America are sent during the day via St. Louis for Praia and Natal; at night they are sent direct or via Natal.

The wave-lengths used are those of the Navigation Aerienne or 26.7 m., 37 m. and 57 m. for the stations on the chief wireless network.

Wireless communication to ensure the safety of the aircraft is on long wave-lengths, by such stations at each aerodrome which have 500-750 watts power, except for certain stations particularly close together, where the power used is only 200 watts (or are in course of construction).

The wave-length for traffic is 1,400 m.

Nevertheless, at the aerodromes where there is known to exist an organisation of the S.N.Aé.—Paris-Biarritz-Toulouse-Perpignan-Marseilles-Aeger-Casa-

blanca-Bordeaux—there is no organisation for long waves, the Government service being used.

The directional wireless network already assured by the existing apparatus at all aerodromes is completed by certain stations on the line of flight of the aircraft (for example, San Juan in the Argentine). This arrangement is, moreover, supplemented in certain cases by stations of the Navigation Aerienne (for example, Oran). All the wireless apparatus owned by the company is for continuous waves. The service is only carried out by telegraphy (continuous or I.C.W.).

2. The apparatus carried by each aircraft for transmission varies from 50-150 watts and for reception from four to seven valves, according to the radius of action of the aircraft.

All the apparatus can in the main be used for long or short waves, the traffic being carried out on C.W. or I.C.W.

In principle the aircraft are equipped with wireless apparatus of 225 watts supplied by a generator with three commutators (8, 20 and 1,500 volts) driven by a small windmill.

This equipment is to ensure transmission in flight, to charge the battery and also for transmission in case of a landing. For this transmission an aerial is slung between bamboo supports carried to the ends of the machine.

Erection and repair shops are in course of construction at Toulouse and Buenos Aires.

This important network is now working regularly and has increased greatly the ease of operation of the route and added considerably to the safety.

Aircraft

The aircraft used are now almost all specially provided by the Société Industrielle d'Aviation Latécoère for the special needs of the Compagnie Generale Aeropostale.

Two types are used; one with an enclosed cabin for four passengers, the other more for postal work but capable, nevertheless, of taking four passengers in an open cockpit; one other variation of the same machine gives a range of 1,400 km. with the smallest commercial load. Both are parasol monoplanes with one pair of struts on each side. The wing and fuselage construction of duralumin spars and tubes follows the standard practice.

Climatic conditions have led the company to carry out research with a view to getting rid of rubber cord shock absorbers. The undercarriages are provided with shock absorbers of two types, one steel springs made by the Société des Forges de l'Ariège, and the other the Messier Oleo gear shock absorber.

The chief characteristics of the aircraft are as follows:—

Latécoère 25.

Total weight	3,285 kg.
Commercial load	824 kg.
Range (at cruising speed)	700 km.
Top speed	190 km. an hour.
Cruising speed	155 km. an hour.

Latécoère 26-2.

Total weight	3,364 kg.
Commercial load	788 kg.
Top speed	195 km. an hour.
Cruising speed	150 km. an hour.

The Latécoère 26-6 is a variation of the same aeroplane, but the weight of fuel carried is increased from 681 to 1,113 kg., the range increased from 800 to 1,400 km. and the commercial load reduced to 260 kg.

All the aircraft use Renault 450 h.p. 12-cylinder water-cooled engines. The bare weight is 350 kg. These engines have enabled the company to carry out a regular service as shown by the figures given later.

The 450 h.p. Renaults have flown 30,000 hours and no disaster or trouble has been caused by engine breakdown, but solely due to the meteorological conditions.

On the route from Buenos Aires to Santiago which, as I have already pointed out, crosses the Andes, Potez 25's with Lorraine 450 h.p. engines are used, the same type as used in the French Air Force.

Actually the company uses new aircraft constructed by the Société Industrielle d'Aviation.

Latécoère 28 is a braced monoplane with cabin accommodation for eight passengers. Its chief characteristics are as follows:—

Total weight	4,040 kg.
Commercial load	950 kg.
Top speed	238 km. an hour.
Cruising speed	200 km. an hour.
Range (at cruising speed)	800 km.

It is fitted with either a 500 h.p. Hispano or a 500 h.p. Renault. Both engines are geared.

I wish particularly to draw your attention to this aeroplane as being the fastest commercial aeroplane in use at the moment, for its speed of 200 km. an hour has not only been maintained, but often surpassed. It is on this aeroplane that the Comte de la Vaulx, President of the F.A.I., flew from Toulouse to Casablanca at 176 km. an hour, including stops, or a speed of 222 km. an hour in actual flying time.

The air fleet of the company consists of about 100 aeroplanes of the Latécoère 25 and 26 types and 17 Latécoère 28's. This number will shortly be increased to 33. To that one must add ten machines of various types of which three Potez are used for crossing the Andes, and 70 machines of older makes held in reserve.

The oceanic crossing between Dakar and Natal is by means of fast boats, which will be used until the Atlantic service has become regular. Six boats have been lent for this purpose to the Company by the Marine Nationale. They are about 1,000 tonnes displacement, and are driven by 6,000 h.p. turbines, and reach a speed of 16-18 knots.

The Company's own fleet consists of these six dispatch boats, of four rescue steamers displacing 350-650 tonnes, two water tankers, two oil tankers, and 10 motor boats.

The Company will put into service, during the summer of 1930, four new units, which will serve the flying boats which will be able to make the air journey across the ocean.

Results

The results obtained are as follows:—

The post takes 8½ days to reach Santiago, against the normal time by other means of transport of about 25 days.

For Montevideo and Buenos Aires the time is 7½ days, against 18 days.

The average time from Natal to Buenos Aires is 47 h. 30 m. and the best time in summer 31 h. 25 m.

From Toulouse to Dakar the average time is 40 hours and the best 27 h. 15 m.

Taken all round the fastest journey in summer has been that of the Comte de la Vaulx, of which the following are the times.

Leaving Toulouse at 6.20, the post arrived at Casablanca in 8 h. 20 m., after landing at Barcelona and Alicante. Leaving Casablanca at 14 h. 45 m., Dakar was reached the following morning at 9.50; from there the journey was

continued on the boat Peronne, reaching Natal at 22.20 h. and from there Buenos Aires was reached on the 23rd at 19.35.

On the route from Natal to Buenos Aires the percentage of scheduled departures to the arranged time-table has been 94 and the percentage of arrivals, less than 48 h. late, has been 82.

On the Toulouse-Dakar section the corresponding figures have been 100 and 90.

These results can only be considered remarkable in the light of the great difficulties which have to be faced from variation of climate and altitude and the working of a line of such great length.

Crossing the Atlantic

It is necessary to consider crossing the Atlantic without landing, for the Cape Verde Islands have no sheltered roadsteads suitable for the getting off of seaplanes.

Saint-Paul Rock and Fernando de Noronha Island are also unsuitable, and further, the latter is less than 300 km. from Natal.

In order to cross the Atlantic the Company has under construction seaplanes of 10 tonnes with a range of 4,000 km. and a commercial load of 500 kg. These seaplanes will be ready during 1930.

Other machines in course of construction should enable a useful load of 1,000 kg. to be carried for the same distance, and then Buenos Aires will be within five days of Paris.

The Line Marseilles—Algiers

Finally I should like to say a few words about the route from Marseilles to Algiers. On this route machines fly six times a week in each direction. Violent and sudden storms make the operation of the route particularly difficult at the end of winter and the beginning of spring over the Mediterranean.

Twin-engined seaplanes, either Cams or Latécoère 32's are used. The Cams are fitted with 500 h.p. Hispanos or geared Jupiters of 480 h.p. The weight all up is 650 kg. and their commercial load 300 kg., top speed 205 km. per hour and average speed 155 km. per hour.

The Latécoère 32's are fitted with 500 h.p. Hispanos, and their top and cruising speeds and commercial loads are similar to the Cams. Their all-up weight is 7,500 kg., and the crew consists of a pilot, a wireless operator and a mechanic. The Company has five Cams and four Latécoères.

The average time for the journey is 5½ hours and the quickest time 3 hours 50 minutes. The percentage of departures to scheduled flights is 86 and of arrivals 80. In this percentage are included those machines which land the same day of leaving.

I have only been able to make an extremely rapid survey of the working of the Compagnie Generale Aeropostale, sufficient, nevertheless, I hope, to give an idea of the organisation necessary to obtain the results of which the Compagnie Generale Aeropostale are rightly proud.

Discussion

The President, after thanking M. Grimault for the paper, and Mr. Bamper for having read it, said that the meeting had been particularly interested by virtue of the tremendous enterprise evinced by the company in establishing a service from Paris, right across the Equator, and through to Chili.

Air Vice-Marshal Sir Sefton Brancker (Director of Civil Aviation): The Compagnie Generale Aeropostale was the child of the Société Industrielle d'Aviation Latécoère. The latter organisation was the pioneer air transport company of the world, he believed, because it had started operations on Christmas Day, 1918,

with a mail service from France to French Morocco. In this it had achieved very great success, because in a short space of time it was carrying practically the whole of the first-class mail matter from France to Morocco. Later the service was extended to Dakar, and subsequent extensions had been made from time to time, and the service as it existed to date represented perhaps the greatest feat of any aircraft undertaking. Not only was this the longest air line, but those responsible for it had had to face the greatest difficulties, both internationally and geographically. It had to cross country of higher altitude than that on any other air transport line, and efforts were being made to establish a regular service across the biggest stretch of sea over which such an attempt had yet been made. . Already its achievements were magnificent, in reducing the time occupied in the transport of mails between Paris and Santiago to 8 or 9 days, and in having run the service with extraordinary regularity during the last year over a very difficult route.

Discussing the organisation at the re-fuelling points on the route, he said he had gathered that when an aeroplane arrived at any of these points *en route* the passengers and mails were transferred as quickly as possible from it to a second machine which was ready to leave. That sounded like a counsel of perfection, but he would like to know what it cost, because it seemed to him that one needed a great many more aircraft if the service was to be operated under those conditions than if each aeroplane travelled over three or four consecutive stages and if the company were content to suffer the delay necessary for re-fuelling. If re-fuelling were properly carried out, however, it should not take very long. If it were carried out by old-fashioned methods whereby a man had to climb up a ladder and fill up the petrol tanks from two-gallon tins through a filter, or if the fuel were pumped from a large barrel, the time would be considerable, but with proper arrangements the re-fuelling of even a big aircraft should not occupy more than five of six minutes.

Discussing the flying boats to be used for the South Atlantic crossing from North Africa to South America, he said he felt that 10-ton boats were rather small for such a task. He personally was in favour of keeping aircraft small, so long as the stages to be covered were fairly short, such as 300 miles, for instance, and of ensuring frequency—maintaining a bigger fleet of faster aircraft—rather than increasing the load of each individual aircraft; but for long jumps across the ocean, something like 1,500 miles, one was forced to use large aircraft. To begin with, aircraft must carry a good deal of petrol, and that could not be carried unless the aircraft were large; secondly, there seemed no opportunity of refuelling at all between Dakar and the South American mainland. Neither the Saint Paul Rock nor Fernando de Noronha Island, nor even the Cape Verde Island seemed to offer any hope of a safe landing. Therefore, it would be necessary to use flying boats which were really seaworthy, and he took the opportunity of suggesting to M. Grimault that he might investigate some of the later designs brought forward in this country, and which were really designed for long distance work across the ocean. They were 30-ton boats, but he believed that for such work we should probably have to go to 40 or 50 tons. The Compagnie Generale Aeropostale had learned the importance of speed on long distance routes, and he supported that absolutely. So far we had been flying at cruising speeds of 80 or 90 m.p.h., but that was not enough for continuous services up to 6,000 or 7,000, or even 10,000 or 12,000 miles, and he considered it would be necessary to attain a cruising speed of 120 m.p.h. That was the only way to cope with adverse winds and to keep time.

Captain SALA (French Air Attaché) (replying briefly on behalf of M. Grimault): The Company had tried the running of each aircraft over long distances, halting at intermediate stations for re-fuelling, but had found that the time occupied in re-fuelling at each landing place was half an hour or perhaps an hour. On the other hand, the time occupied in transferring mails and passengers from one

aircraft to another was about five minutes. If one aeroplane were used to cover a long distance, and had to stop at intermediate points for re-fuelling, the total flying time lost during a day as the result of the delays at the re-fuelling points would be perhaps 1½ or 2 hours, and that delay might make it impossible for a machine to cover its scheduled distance during daylight, and it might miss the next boat connection. With regard to the flying boats for the South Atlantic crossing, he said that the 10-ton type was experimental, but the Company was considering the use of aircraft of perhaps 20 tons later on, having a useful load of one ton.

Mr. F. Handley Page: With regard to re-fuelling, he pointed out that if an aircraft was carrying more petrol than useful load it should be very much quicker to change the useful load than to refill with petrol. He would be much better pleased, however, if he were told it was found much easier to put in a little petrol than to transfer a lot of goods and passengers. It seemed to him that if there were very little goods and a great deal of petrol, that constituted a reflection upon the service. In regard to cruising speed, M. Grimault had stated that the machines used by the Company originally had had a cruising speed of 155 km. per hour—a little less than 100 m.p.h.—but the later machines had a cruising speed of 200 km. per hour. He asked if that change had been necessary by reason of adverse winds and other climatic conditions having been experienced, *i.e.*, if it had been found that the regularity of the service was affected if the cruising speed of the machines were only 155 km. per hour. He agreed with Sir Sefton Brancker that a cruising speed of 90 or 100 m.p.h. was not sufficient now-a-days, and if we could obtain a cruising speed of 125 m.p.h., even though it might mean a decrease in paying load, he believed that in the long run the saving in time would make up for it, because one can run more services in the course of a day. With regard to cost, when one saw what a big wireless system was used, extending all over the service, and paid for by the Company—happily in this country the wireless service was paid for by the Government—one wondered how much the wireless service cost per mile flown. It seemed comparable to the cost of the signalling service of a railway system. He also asked what was the actual cost per ton-mile of the service right the way through. Considering that at each landing place there was a machine always in reserve, and that there had to be maintained a large number of mechanics and a great organisation, with boats, tankers and so forth, it seemed to him that the operation of the service would be rather costly. If the whole of that organisation were assembled at one spot he imagined it would make a very good beginning for the fleet of a second-class air power. He did not say that in any disparaging spirit, but was merely anxious to know what sort of commercial results were attained. The total receipts in 1919 were 18,524,929 francs, of which 16,881,789 francs constituted the receipts for the postal services. He would like to know the ratio of subsidy received to the actual commercial results, including any special subsidy paid by the Post Office for the carrying of mail beyond the actual receipts from the senders of the letters. The percentage of arrivals was given as 82 per cent. and that seemed to be rather low. If 18 per cent. of the letters sent by railway or steamship did not arrive, he imagined there would be a big outcry. He asked whether it had been found during the operation of the service that the mail patronage had rather dropped off during times of adverse weather conditions, just as there was very often a decrease in the number of passengers carried by aircraft after an accident had occurred. With regard to the South Atlantic crossing, he asked if it would be possible to develop the Saint Paul Rock as a seaplane harbour, because it seemed to him that they had been very fortunately placed by nature in the centre of the South Atlantic and one would wish that nature had provided the North Atlantic ocean with similar facilities It might be, of course, that there was no possibility of developing it. He congratulated M. Grimault and his Company upon the extraordinarily good service

they had organised, particularly bearing in mind the difficulties with which they had had to contend. When he had seen photographs of the valleys and rocks exhibited by M. Grimault, he had been reminded of a remark by Commander Diaz in a paper dealing with aviation in Peru, that it seemed that no aircraft could hope to survive a forced landing in such country unless it had claws as a landing carriage.

In this country they had tied themselves to the fog difficulty; they were apt to say that no other services had to contend with such difficulties, and that once they were South of the Alps all was beautiful, and he had always imagined that when one flew south of Marseilles one flew into an aerial Paradise, in which there was no fog and no mist, and where visibility was good for 50 or 60 miles. It was rather illuminating to find that sometimes the conditions there were almost as bad as in this country, and they would have to give up their ideas about the one kind of monopoly that they still possess, *i.e.*, bad weather.

Sir VYELL VYVYAN: He presumed that the most difficult part of the Company's route was that between Buenos Aires and Santiago, and asked whether it had been found necessary to use supercharged engines there, in view of the high altitudes that had to be attained. There was no question that speeds must be increased largely; the average speed of the air mail throughout the whole journey from this country to India was only 30 m.p.h., and that was not very much. There was no night flying on that route, but he asked M. Grimault what developments were expected in the direction of night flying on his Company's lines. We were rather behind in that respect. He also asked whether M. Grimault considered that, when the speeds were increased, there would be a tendency to separate the fast mail traffic from the passenger traffic, because then the machines most suitable for each class of traffic could be used, and one could speed up the mail traffic more easily than the passenger traffic, because in the latter case regard must be had to the comfort of the passengers. He believed that in America the mail traffic had been separated from the passenger traffic originally, though some combination had been effected since.

Air-Commodore CHAMIER: Did M. Grimault hold a brief for water-cooled engines, because the Company were using this type of engine entirely, whereas Imperial Airways, Ltd., were reported to be thinking of having nothing but air-cooled engines. He also asked if night flying were resorted to generally throughout the aeropostale service.

Commenting upon the figures given in the paper, he said they were of great interest, but some of them were rather queer. For instance, he had noted that a very small percentage of the total weight of postal matter carried—about 10 per cent.—was for delivery in America, and that was very disappointing. The transport of postal packets by air over comparatively short journeys effected a saving of only a day or two, but when postal packets could be transported from one side of the world to the other in a few days the saving of time was very great, and one would have thought that that would have appealed to the public and that the percentage of long-distance mail carried would be very high. It was to be noted, however, that the percentage of long-distance mail was increasing. The results in regard to the loads carried seemed extraordinary in one respect. There were over 100 aeroplanes on this service and their load capacity was about 100 kg. per flight; the total amount carried during the year 1929 was 200 kg. By a simple calculation he concluded that it required each aeroplane to fly once in the year with a full load in order to transport the whole of it. That sounded terrible for aviation.

Major BULMAN: He had noted the preponderance of the water-cooled engines on the Company's aircraft, but he gathered that the Jupiter had been undergoing trials recently, and he asked if M. Grimault could give some information as to how it compared with the water-cooled engines. He asked also whether the water-cooled type of engine had been used for so long because there was no air-

cooled engine of the right power available, or whether the factor of fuel consumption was an important consideration. A few days ago, when discussing the D.O.X. machine at Messrs. Dornier's works at Friedrichshafen, he had been told that Messrs. Dornier's were quite reasonably satisfied with the air-cooled type of engine from the points of view of power and reliability, but that for very long flying ranges they simply had to use the water-cooled engine. It might be, therefore, that under those circumstances the water-cooled engine would survive for some time yet. With regard to supercharging, one imagined it would be required in some form on machines which had to cross the Andes, where an altitude of 15,000 ft. had to be attained. Discussing lubricating oil, he was particularly interested in the fact that the Company was using castor oil in place of mineral oil, because that was directly contrary to what was being done at the Air Ministry in this country. There were a number of engines which had been running on mineral oil throughout their history, as, for instance, the Liberty and the Curtiss, and they had run perfectly successfully. During the last two years a great number of type tests and flight trials had been made of practically every British engine on mineral oil, and the Air Ministry staff had satisfied themselves that its use was advantageous. It was cheaper than castor oil, and for certain air-cooled engines they considered that it was actually better, provided that, in arriving at the various clearances, and so on, in the engine adequate allowance was made for the reduced viscosity. It was something of a shock, therefore, to find that apparently the tendency was in the opposite direction elsewhere. An engine which had been running on mineral oil for 100 hours or so looked very much dirtier than one which had run on castor oil, and someone had said that the engine which had run on mineral oil would look as though a barrel of tar had been thrown into it, but, at the same time, it was adequately lubricated. With regard to the oil system, he asked whether any form of oil filter was used on the Company's machines, particularly on desert routes, and also whether any oil cleaner was embodied in the installation in order to take out of the system any foreign matter that might get into it, because it seemed that that was a most important factor. He gathered that on the Company's machines the period between overhauls was in the neighbourhood of 250 hours, and that was fair for the present day, but he believed that we could claim something rather better on British routes. His ambition, especially in respect of the flying boat type of aircraft, was to have an engine which would run 1,000 hours without overhaul, and he believed that if we set that standard to-day we should get there within no more than, say, two years. In the course of discussions on this matter, however, the question had been raised as to whether, having got an engine which would run for 1,000 hours without overhaul, the engine would outlive the aircraft itself, *i.e.*, if the aircraft had to be overhauled at least once in 500 hours, why bother about having an engine which would last 1,000 hours?

Dr. MERTON (Chairman, Executive Committee of Air League of the British Empire): He gathered that the wireless stations were situated mainly on the actual line of flight. If that were so, he did not see how there could be effective intersection of the bearings, and hence, exact information as to position. He asked if M. Grimault could give more particulars of the total mileage flown on the routes, in order to complete the statistical data. He gathered that the term "seaplanes" used in the paper meant machines of the type which we referred to usually as flying boats.

Mr. RATCLIFFE: Commenting on the fact that the machines used by the Company were constructed of duralumin, asked what steps were taken to guard against corrosion, having in view the fact that the machines operated along the coasts of Africa and South America, where the conditions must be very severe for such material. He also asked if anything had been done in the way of sound-proofing the passenger-carrying machines.

Herr SCHEPENBERG: There had in the past been many political difficulties which had been experienced from time to time when aeroplanes had been forced to land in various places along the African coast, and he asked if any improvement had been effected in that respect during the last year or so.

Mr. PYE (Deputy Director of Scientific Research at the Air Ministry): He hoped it would be possible for M. Grimault to give some definite figures with regard to fuel consumption. In this connection he recalled that at the end of the Great War, or soon after, a figure that had been given as representing the air mileage per gallon for a large twin-engined machine was $30{,}000/W$ where W was the weight in lbs., and it would be extraordinarily interesting to have a figure relating to modern conditions to compare directly with that previous figure. In spite of the remarks made by Air-Commodore Chamier, he asked for information with regard to maintenance costs, particularly in regard to engines and the relative importance which M. Grimault attached to maintenance costs and fuel costs, and he also recalled that the reader of a paper before the Society had quoted a figure of 17s. 6d. per flying hour as the all-in maintenance cost of a well-known air-cooled engine. Such figures were of extreme interest. Again, he expressed the hope that more papers of the type presented by M. Grimault would be presented to the Society in the future, because it was only by studying the results attained by a large organisation such as his Company that one could glean the necessary data on which future technical development must be based. Civil aviation hitherto had been tied much too much by the apron strings of the fighting services. If civil aviation were to develop as it should, however, it must have a technical development of its own, and if it were to have a proper technical development of its own the men responsible for that development must have the data available. No fighting service could give the kind of data which were obtainable as the result of long continued flying under more or less standardised conditions, and those were the data which civil aviation needed for its proper development. He hoped such data would be forthcoming from those responsible for civil air routes both in this country and abroad. Everyone attending the meeting must have been impressed, as he had been, by the immense amount of successful organisation and technical adjustment that must have been applied to the development of the routes of the Compagnie Generale Aeropostale.

The PRESIDENT: Commenting upon the plea made by Mr. Pye to those responsible for the direction of air transport organisations to provide the information necessary for the proper development of civil aviation, he directed the attention of Sir Vyell Vyvyan particularly to that plea and asked that he would transmit it to the Board of Imperial Airways, Ltd., of which he was a representative. For seven years or more the Society had been trying to get information of that character, because it was required by designers of aircraft and aircraft engines in this country, but so far without success. Men of experience and great technical standing, such as M. Grimault, had come from France, and from Germany and elsewhere, and had given a good deal of the results of their experience, but the Society had not been able to persuade anybody from Imperial Airways House or from Croydon Aerodrome to say what they thought about it. That was a state of affairs which certainly should be remedied.

Sir VYELL VYVYAN: He would transmit the President's message to the proper quarter.

The PRESIDENT: Dealing with the question raised by Major Bulman with regard to the respective merits of castor oil and mineral oil for lubrication, he said that M. Grimault had stated that the price of castor oil was less than that of mineral oil throughout the Company's routes, and for that reason the Company was keen to use it. He had also stated, however, that if the price of the two types of oil were the same, he would certainly use castor oil, because it gave rise to far less deposition of tarry matter and gummy residues on the crankshafts of engines.

Reply to Discussion

First of all, I would like to say that it is impossible for me to reply to questions of a financial nature as our Company does not desire to make such information public.

Air Vice-Marshal Sir Sefton Brancker.—In order to reduce the number of machines necessary in service, the Compagnie Generale Aeropostale are at the moment attempting to increase the radius of action of the machines and to lessen the number of stages.

At the moment the stages can be approximately 1,000 kilometres in length. The Company thinks it necessary to have at least one machine in good flying order at each stage to meet any eventuality.

I agree with General Brancker that for a regular service over a long distance it is necessary to have large size flying boats. The Company is at the present time examining the performances of large flying boats constructed in different countries, but owing to the delay in construction and testing, it has been thought preferable to make trial flights and commence the service with hydroplanes of less tonnage.

Mr. Handley Page.— The useful load in the machines used by the Company is in proportion to the extent of the traffic, but machines which are being constructed will allow for the carriage of a greater amount of useful load with the same radius of action.

The speed of 200 kilometres has been found necessary in order to cover the distance between Toulouse and Casablanca as often as possible on the same day.

The regularity is better with faster types of aircraft.

With regard to the cost of the wireless, I would only say that the installation of the wireless system has considerably reduced the expense of cables which were necessary before the wireless was installed, and a great deal of expense of the wireless organisation would have been eaten up by the cost of cabling had wireless not been installed.

The amount of mails carried does not vary much owing to bad weather.

St. Paul rocks cannot be used as a base for flying boats.

Sir Tyell Tyrvan.—Superchargers are not used when crossing the Andes.

Night flying is being continually carried out on the air route. The ordinary time of departure from Buenos Aires is midnight.

On each trip between Buenos Aires and Toulouse there are about ten hours of night flying.

The Company has not yet thought of separating the passenger service from that of the carriage of mails although possibly this will be considered in the future.

Air Commodore Chamier.—Water-cooled engines have been adopted by the Company not on any question of principle, but on a question of opportunity, taking into consideration the price of engines constructed in advance.

The weight of mails carried to South America is, as stated, small when compared with the total weight of postal matter sent to that continent. This is due to a large extent to the fact that the Toulouse-Casablanca service is a daily one, whereas the service to South America is only weekly. People in Morocco have acquired the habit of regularly using the air mail, but it is more difficult to reach the wider public who are interested in South America. Nevertheless, on this route, the weight of mails carried is increasing regularly and will make considerable progress if the air crossing of the Atlantic turns out to be satisfactory.

Major Bulman.—I have already replied regarding the question of air-cooled and water-cooled engines.

Petrol consumption is more or less the same for both types of engines, but the oil consumption is greater for air-cooled engines.

Castor oil is used because it is cheaper than mineral oil and because it has been found that castor oil causes less gumming up of the piston rings than when mineral oil is used.

The Renault engine carries a centrifugal oil strainer.

If an engine could run for 1,000 hours without overhaul it would certainly be adopted with enthusiasm. Present-day aircraft have a life at least equal to this.

Dr Merton.—Lateral radio stations are installed whenever possible in order to obtain positions of aircraft through direction finding. Where these stations cannot be established one cannot get the exact position, but one is able to obtain direction, which in itself is an important consideration.

The French word "hydravion" corresponds to the English expression "flying boats."

Mr. Pye.—No comparative figures are available regarding the characteristic mentioned by Mr. Pye.

Figures cannot be given for the cost of upkeep of engines, and all that can be said is that this cost is not negligible in proportion to the price of the fuel.

Herr Scherpenberg.—The political situation along the coast of Rio de Oro is still about the same.

Mr. Ratcliffe.—The duralumin which is used is protected by the varnishes which are usually used, and no particular corrosion has been noticed in South America.

In order to lessen the noise in the cabins the engines are provided with silencers.

Certain companies have tried different kinds of linings on the cabin walls and these seem to have improved matters.

ELEMENTS OF DETAIL DESIGN

BY

FRANK RADCLIFFE, B.Sc., A.M.I.A.E., A.R.Ae.S.I.

(*Received May*, 1930.)

I. Introduction

British aircraft engineering has reached a stage in its development when one is safe in saying that:—

(*a*) The aerodynamics of flight is appreciated and understood to a satisfactory extent;
(*b*) The methods of determining the loads likely to be present in the primary structural members are reliable;
(*c*) The change over from wood to metal construction is, for all practical purposes, a reality; and
(*d*) Suitable ferrous and non-ferrous materials of construction available for use by aircraft constructors have been standardised and proved to be reliable and consistent in quality.

But with all this widened knowledge and experience there is one section which, the author claims, still needs more careful attention than it has received in the past, viz., the design of joints and fixings for primary structural members in general. If the joints will not stand up to their work there will be failure with, possibly, disastrous results, and if weight is thrown away unnecessarily the useful load which the aircraft can carry is diminished and its successful sale handicapped.

The recent Aero Exhibition at Olympia enabled the author to see how British constructors were dealing with *detail design*. Diversity of method was one of the main features noticeable from an inspection of the various types. Most firms had their own particular methods of construction, and whilst some details exhibited showed great mechanical ingenuity they were often at the expense of manufacturing costs. Others had extremely simple fittings thoughtfully standardised and involving only a small sacrifice in added weight. The author's experience of aircraft design from the drawing office side and from the checking and examination of structural members and joints leads him to believe that an attempt on his part to put forward a constructive criticism of present-day design may be a contribution of some utility and, whilst he cannot hope for general agreement on all the points raised, he would gladly receive and appreciate the views of others with a view to getting a better understanding of this important section of design.

It seemed essential from the outset that a few notes should be given on what the *design loads* in a member mean and this involves a section on Load Factors, and their significance. Then come the queries regarding fundamentals of design which meet one every day:—

(*a*) "What material shall I use here—mild steel, duralumin, or high tensile steel?"
(*b*) "What bearing pressures will be safe for this material or that?"
(*c*) "Is it safe to work on the ultimate strength of the material or on the yield strength in designing a member to take this load?"

These are three questions that are very typical of the queries raised, and they bring up some very interesting points for a more detailed consideration that will be found under appropriate headings.

It is, of course, appreciated that one can easily be too dogmatic and so the author writes hoping that what he says will be accepted as his current views and subject to amplification, qualification or modification as time or added experience indicates

II. British Load Factors and their Significance

It is important that the meaning and significance of a *Load Factor* be appreciated and the simplest way of stating it seems to be that it represents approximately 1½ the maximum ultimate load that is likely to come into a member under the various aerobatics. It is possible that the *actual load* could be exceeded by some unusual and extraordinary manœuvre attempted by the pilot and this has then a chance of being covered by the 33⅓ per cent. increment used for fixing the design load—assuming that the material is as strong as specified by its appropriate specification. This leads us to one of the fundamental conceptions of aeroplane structural design, and its application will be shown later.

The load factors which have to be covered in a British aircraft are laid down by the Air Ministry for civil types and are stated in the specification for Service types. The principles upon which they are based are to be found in R. & M. 776[1], and to this report the reader is referred for a fuller account. When this Report was issued, in 1922, certain theories, which are now commonplace, were not accepted, and it speaks well for the committee which framed it that, after eight years, it still remains sensibly unaltered.

Since 1922, the art and skill in flying have been improved and with the high performance aircraft of to-day the accelerations set up have been increased. Records of the accelerations registered in performing certain aerobatics together with details of the service history of various types have enabled valuable data to be collected for judging whether present factors are high enough. It is interesting to note, in passing, that there has been a steady increase in the load factors for racing aircraft and fighting types, whilst in civil types the factors called for in the Terminal Nose Dive conditions appear possible of a reduction, especially when continental evidence proves conclusively that lower factors than those required by the British Air Ministry are proving quite satisfactory.

In a recent paper before the R.Ae.S. by Mr. Howard[2] reference is made to the fact that our knowledge of the accelerations set up in British air transport aircraft is practically nil and until this is known it seems probable that reductions of factors in normal category aircraft will not be possible. It is to be hoped, therefore, that this deficiency in our experimental knowledge will be removed at the earliest possible moment so that further economies may be achieved by a reduction in load factors with a consequent increase in the available pay load.

With the bigger types of aircraft the advantages offered by strain energy methods of solving complicated structures are often made full use of and in this way what was formerly a means of additional strength is now removed. This has resulted in the recommendation that when strain energy is resorted to as a means of determining the loads in a structure that an additional reserve factor of 20 per cent. be provided in the members so designed. As other countries have formulated their own scheme for assigning necessary load factors on different fundamental ideas from ours it is intended that what follows, having reference to stressing, should be taken as applying to British practice only and relates to those assumptions as outlined in the Handbook of Strength Calculations (A.P.970 Third Edition) and the Civil Airworthiness Handbook (A.P.1208).

III. The Problems of the Aircraft Draughtsman

The aircraft draughtsman in the course of his scheming of the joints for the structure of a projected aircraft has three distinct problems with which to deal. They are:—

(1) The type of construction to adopt.
(2) The materials from which to build the joints, and
(3) The working stresses that should be employed in design calculations.

(1) It is probably correct to say, in general, that the type of joint construction is determined from the commencement by the Chief Designer who, from previously accumulated experience, knows what type will prove most satisfactory in service, will be easy to produce in the shops by virtue of its simplicity, or cheapness, and/or will enable existing jigs and tools to be utilised. As regards fuselage construction, for example, the Aero Show at Olympia proved that there does not seem to be a consensus of opinion for proving any one type the best as each designer has his own scheme.

(2) At the present time there appears to be a distinct move towards the adoption of high tensile steel in all its existing forms for both fittings and bolts, and where operational conditions warrant the utilisation of non-corrosive steels. In Tables 1, 2 and 3 are given a comprehensive list of the materials the aircraft designer has at his disposal and it is at once evident that there will be right and wrong materials for a specific purpose. An attempt will therefore be made to suggest the right material.

(3) In conjunction with (2) there is always present with any new material an uncertainty as to what working stresses can safely be allowed. This is a very real problem and with the introduction of so many new materials it is becoming acute, for if one does not get a satisfactory solution one is confronted with (*a*) throwing away unnecessary weight by being prodigal with the use of the material, or (*b*) having a false idea of the strength of the joints. It would appear, therefore, that mechanical tests should be resorted to, in order to test out new schemes. In this way it is possible to accumulate reliable data for filling in the gaps in one's experience.

IV. Standard Specifications and the Information Contained Therein—with its Significance

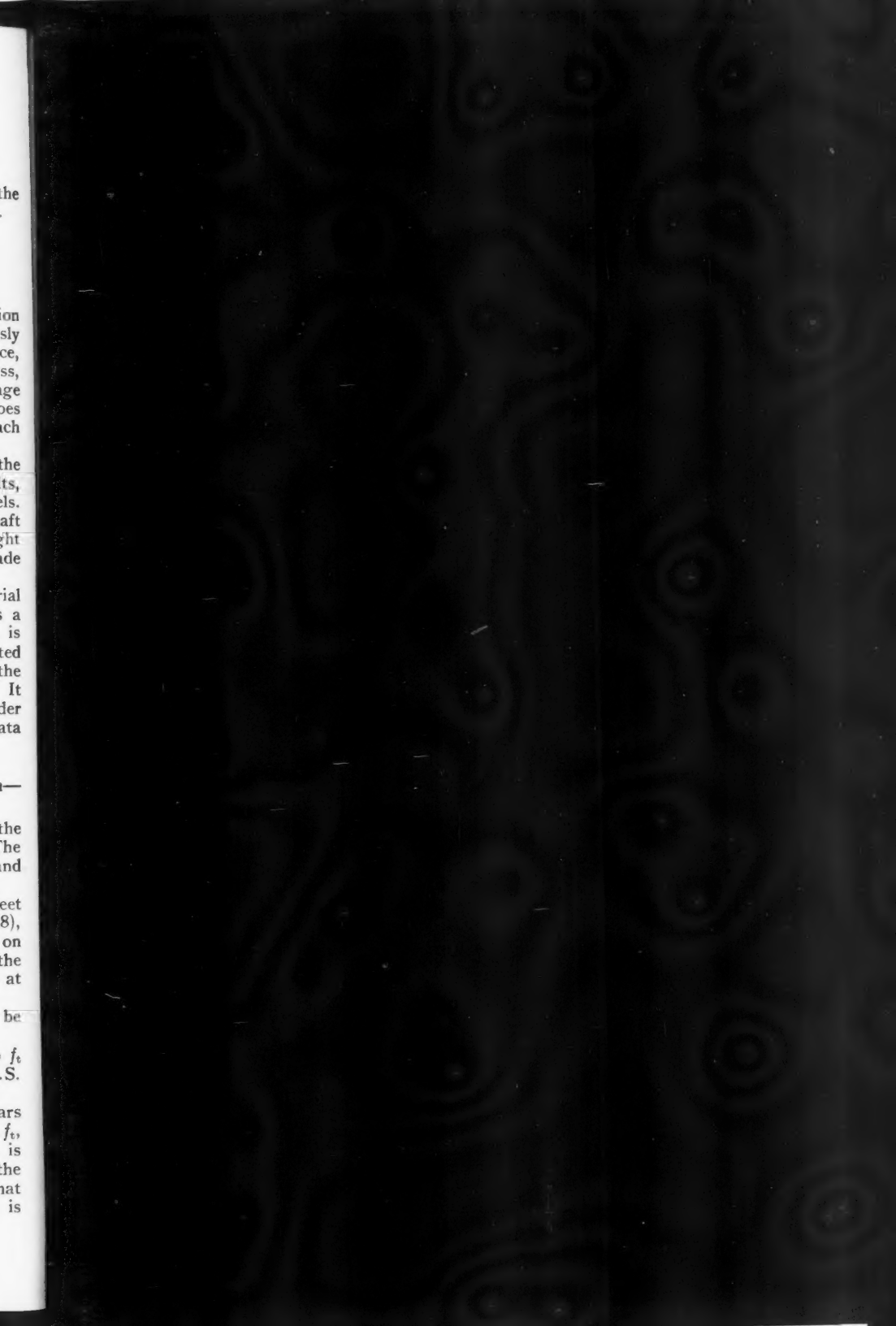
In Tables 1, 2 and 3 are given a precis of the information contained in the specifications issued by the B.E.S.A. and the Air Ministry (D.T.D.). The headings are sufficiently clear for further explanations to be unnecessary and it now remains to discuss briefly the significance of the columns.

Referring now in particular to Table 1 which deals with steels in bar, sheet or strip form, there is not much that can be criticised until we come to column (8), which deals with the shear strength of the material. As a result of tests on pins and rivets in plates, it would appear that a conservative estimate of the shear strength of all kinds of steel is at least 0.6 f_t, but this statement needs at least two qualifications.

(1) For mild steel a higher value, up to as much as 0.75 f_t can safely be assumed, due probably to the yielding of the material under load.

(2) For a high tensile steel (which has no characteristic yield point), 0.6 f_t should be used. The special case of the shearing of rivets in very thin H.T.S. plate is treated in the last section of this paper.

Column (9). It has been standard practice among designers for many years to assume that the crushing, or bearing strength of steel is of the order of 1.5 f_t, and whilst this has proved quite a conservative value for mild steels there is some uncertainty with H.T.S. in very thin gauges. It would appear that the stress set up under the crushing action of a pin on a plate is complex and that higher bearing stresses can be obtained, within limits, as the shear stress is



①	②	③	④	⑤	⑥	⑦	⑧	⑨
Material	Corrosive or Non-Corrosive (NC)	Specification		Strength Values				
		BESA	DTD	$E/10^6$	f_c	f_y / f_p	f_s	f_b
Bright Steel Bolts & Nuts		A1		30	35	20y	23	52.5
Bright Steel Bars		S1						
55 Ton Alloy Steel Bar		S2		30	55	42.5p 45y	34.5	82.5
Hot Rolled M.S Sheets for Welding		S3		30	28	20p 18y	20	42
.5% N.S Sheets		S4		30	48	36p 34y	28	72
40 Carbon Steel (Normalised)		S6		30	35	20y	23	52.5
Tinned Steel Sheets		S20		30				
High Cr Steel	NC	S61		30	35	26p	23	52.5
High Cr Steel	NC	S62		30	46	34p	25	69
65 Ton Ni-Cr Steel		S65		30	65	54p	39	97.5
40 Carbon Steel (H & Temp)		S76		30	40	23y	24	60
High Cr Steel Bar	NC	S80		30	55	45p	33	82.5
Streamline Wires		W3		30	55	45y	33	82.5
Tie Rods		W8		30	52	42.5y	30	78
N.C Steel Sheets	NC		23B	30	30		18	45
N.C Steel Rivets & Split Pins	NC		24A	30	30	15p	18	45
N.C Low Tensile Steel Sheets	NC		39	30	28		18	42
Special Cr Ni N.C	NC		42S	30	40	9p 15y	24	60
Steel Sheets	NC		42H	30	55	32p 35y	33	82.5
Special Cr Ni Steel	NC		43S	30	40	9p 15y	24	60
Bars	NC		43H	30	45>t2 50<t2	22y 22y	30	75
N.C Steel Strip	NC		46S	30	≯ 45		27	67.5
	NC		46H	30	86.7	65p	53	132
N.C Low Tensile Steel Bar	NC		53	30	28	18	18	42
High Tensile Ni-Cr			54A S	30	55	42.5p	33	82.5
Steel Strip			54A H	30	80	65p	48	120
Cr Ni N.C Steel Strip	NC		57B	30	54	40p	32	81
High Cr N.C Steel Sheet & Strip	NC		60A	30	55	45p	33	82.5
High Tensile Ni-Cr Steel Sheet			98	30	55	42p	33	82.5
Ni-Cr Steel Strip			99	30	65	55p	39	97.5
Hardened & Tempered			100	30	50	40p	30	75
Silco-Mn Steel Bars			115	30	90		54	135
C Steel Strip 40 Tons f_p for Welding			124	30	50	40p	30	75
C Steel Sh+Strip 50 Tons f_p			137	30	65	50p	39	97.5
C Steel Sh+Strip 65 Tons f_p			138	30	80	65p	48	120
Cold Rolled M.S Sheets			141	30	20			
N.C Steel Sheet & Strip	NC		144S	30	35	9p	21	52.5
High Cr N.C Sheet & Strip	NC		146	30	40	30p	24	60
N.C Steel Bar	NC		156	30	35	9p	21	52.5

TABLE 1

⑧ ⑨ ⑩ VALUES				⑪	⑫ ⑬ ⑭ ⑮ MECHANICAL TESTS				⑯ CHEMICAL COMPOSITION							
	f_s	f_b	FATIGUE $\pm f_f$	REMARKS	% ELONG^N	% R^D IN A	IZOD ft lbs OR BEND TEST	BRINELL	C	Si	Mn	S	P	Ni	Cr	ETC
	23	52·5	±16·5	⑩ UP TO 3/4" ⑩ 3/4 — 1 1/8 ABOVE 1 1/8	15	40	40 / 25 / 20		15-4	3	5-9	05	05	—	—	—
P	34·5	82·5	±31 H	⑩	18	50	40	241-293	—	—	—	—	—	—	—	—
	20	42	±12	⑩ FOR WELDING	—	—	14·9 & THINNER 3 REVS / 140-108 2 REVS		2-25	3	6	05	05	—	—	—
	28	72	±21·5	WORK IN ANNEALED CONDITION NOT SUITABLE FOR WELDING	—	—	—	—	25	3	6	05	05	4·5-5	½·2	—
	23	52·5	±13·8 H	⑩ THIS BECOMES 9·75 WHEN HEAT TREATED	20	40	20	146-201	35-45	3	12	05	05	UP TO 1·0	—	—
					—	—	—	—	13	—	5	07	07	—	—	—
	23	52·5	±16·5	CANCELLING DTD 21	25	50	45 UP TO 2 / 25 > 2"	152-207	15	5	—	—	—	1·0	12·0	—
	25	69	±21	CANCELLING DTD 22A	20	45	35 < 2" / 20 > 2	207-235	15-35	5	—	—	—	1·0	12·0	—
	39	97·5	±31	⑩	17	40	35	293-321	22-28	3	35	05	05	2·75-3·5	1·0-1·4	Va. 25 MO 65 TU 1·0
	24	60	±19	THIS IS S6 WHEN NORMALISED	22	40	35	174-223	35-45	3	12	05	05	UP TO 1·0	—	—
	33	82·5	±27	⑩ CANCELLING DTD 76	15	—	25	241	·25	5	1·0	—	—	1·0	16-20	—
	33	82·5	±25	⑩ 4 BA & UNDER 13/32	—	—	—	—	4·55	3	5·9	·05	05	—	—	—
	30	78	±25	⑩ 13/32 TO ½	—	—	—	—	5·6	3	5·9	05	·05	—	—	—
	18	45	13·5		15	—	< 106 - 2 REVS / > 106 - 1 REV		15	5	—	—	—	1·0	12·0	—
	18	45		⑩ CAPABLE OF HEADING UP WITHOUT CRACKING	25	—			—	—	—	—	—	—	12·0	—
	18	42	±12	⑩	—	—			1	5	—	—	—	1·0	12·0	—
	24	60	±18	NOT TO BE WELDED, BRAZED OR SILVER SOLDERED, USE	30	—			2	·6	·6	—	—	6-10	16-20	—
	33	82·5	±27	DTD 60A OR 580 & HEAT-TREAT AFTERWARDS	20	—										
	24	60	±18		30	—	50		2	6	6	—	—	6-10	16-20	—
	30	75	±22·5	ANKA OR STAYBRITE	25	—	40									
	27	67·5	±21						12-16	·5	—	—	—	1·0	12	—
P	53	132	±39	⑩												
	18	42	±12		20	—	25	131-170	·1	5	—	—	—	1·0	12·0	—
P	33	82·5	±27						25-35	3	45-7	05	05	3-5	5-15	Va. 25 MO 65 TU 1·0
P	48	120	±40	⑩												
P	32	81	±27	SUPERSEDING DTD 57A					18	8	1·0			6-12	14-20	15W150
P	33	82·5	±27	⑩					2	8	1·0	—	—	½ 1·0	18-20	—
P	33	82·5	±27	EQUIV OF S4					35	3	7	05	05	3-5	5-15	Va. 25 MO 65 TU 1·0
P	39	97·5	±31	SUPERSEDING DTD 16 S5IA					25-35	3	45-7	05	05	3-5	5-15	Va. 25 MO 65 TU 1·0
P	30	75	±25	⑩ SUPERSEDING DTD 16 S52A												
	54	135	±43		10			401-444	46-56	16-21	8-13	04	04	4	10	—
P	30	75	±25						3	3	1·75	05	05			
P	39	97·5	±31						5	3	1·75	05	05			
P	48	120	±40													
				FOR LOW STRESS PARTS								05	05			
	21	52·5	±16·5	SUPERSEDING DTD 42												
	24	60	±18						2	6	1·0			1·0	16-20	
	21	52·5	±16·5	SUPERSEDES DTD 43	30		50		18	8	1·0			6-12	14-20	15W150

TABLE II.

MATERIAL	CORROSIVE OR NON CORROSIVE	SPECIFICATION B.E.S.A.	SPECIFICATION D.T.D.	STRENGTH VALUES $E/10^6$	f_t	f_y / f_p	f_s	f_b	FATIGUE $\pm f_f$	REMARKS	CHEMICAL COMPOSITION C	Si	Mn	S	P	Ni	Cr
35 TON CARBON STEEL TUBES		T1		30	35	30 P ±30 y	24·5	52·5	± 16	● ANNEAL BEFORE WELDING FOR SOFTENED TUBE SEE T.61	·3						
Ni. Cr AXLE TUBES		T2		28·7	85	65 P	47	127·5	± 38	● AXELS WEAKENED WHEN DRILLED EACH AXLE TO BE PROOF LOADED							
50 TON CARBON STEEL TUBE		T5		30	45 30(W)	45 y 40 P 18 y(W)	29·5	75	± 22·5 ± 13·5 W	● WHEN BRAZED OR WELDED							
TEMPERED C. STEEL AXLE TUBES		T14		28·7						EACH AXLE TO BE PROOF LOADED							
ANNEALED C STEEL TUBES		T21		30	28	18 P 18 y	18	42	± 12·5	● FOR BLUED TUBES SEE T1	·3						
MILD STEEL TUBES		T26		30	20	11 y	12	30	± 9	FOR BLUED TUBES SEE T6 DTD41	·15						
M.S. TUBES FOR WELDING			41	30	30 30(W)	26P28y 17P17y(W)	22 22(W)	45 36	± 13·5 ± 11	REINSTATING T6	·18	·3	1·5	·05	·05	—	—
ROUND CARBON STEEL TUBES FOR WELDING			89A	30	45 30(W)	40 y 28 P 25 y(W)	26·5 22·5(W)	67·5 45(W)	± 20 ± 13·5(W)	● R.D ONLY SEE DTD 113 ALL TUBES DOWN TO ½" DIA	·3	·3	1·5	·05	·05	—	—
50 TON STEEL TUBES			91A	28·6	50	±40 y	30	75	± 22·5	NOT SUITABLE FOR WELDING DUE TO HARDENING	·5	·3	1·5	·05	·05	UP TO 3·75	—
LOW TENSILE N.C. STEEL TUBES	N.C		97	30	28	18 P 18 y	18	42	± 12·5	● EQUIV. TO T21	·15	·5	—	—	—	1·0	12
35 TON N.C. STEEL TUBES	N.C		102	30	35	30 y^P	24·5	52·5	± 16	● EQUIV. TO T1	·15	·5	—	—	—	1·0	12
50 TON N.C. STEEL TUBES	N.C		105	30	50	40 y^P	29·5	75	± 22·5	● EQUIV. TO T5	·15	·5	—	—	—	1·0	12·0
SECTION TUBES OR SMALL TUBES FOR WELDING			113	30	35 30(W)	30 y 25 y(W)	23 18	52·5 45	± 16 ± 13·5(W)	● FOR TUBES BELOW ½"D ABOVE ½" DIA USE DTD 89A	·3	·3	1·5	·05	·05	—	—
WROUGHT ALLUM ALLOY TUBES (DURAL)		T4		10·5	26 25 (T)	16·5 P 15 (T)	16	32		● T: HEAT TREATED 864 LINDEX DURING 064 - 104 WORKING ABOVE 104	CU 3·5 - 4·5 MN 4 - 7 MG 4 - 7 (FE + ·75)						
HARD DRAWN SEAMLESS BRASS TUBES		T18		15	25	17·6 P					CU 70 SN > 1·25 THE REST TOTAL IMPURITIES > 75						
COLD DRAWN PHOS. BRONZE TUBES.			79		25	20					SN 4·5 - 5·5 P 1·5 - 3 TOTAL IMPURITIES > 25						

TABLE III.

MATERIAL	SPECIFICATION BESA	SPECIFICATION DTD	STRENGTH VALUES E/10⁶	ft	fy / fp	fs	fb	FATIGUE ±ff	REMARKS	MECHANICAL TESTS % ELONG⁰	MECHANICAL TESTS % RIN A	CHEMICAL COMPOSITION.
WROUGHT LIGHT Al ALLOY BAR	L1		10·5	25	15 P	16	32	± 10	⊗ SG 2·85 UP TO 2⅜" BARS	15	20	
DURAL BAR	L1		10·5	22 20	12 P 10 P	16	32		⊗ 2⅜" - 4" 4" - 6"	15 15	20 20	Cu 3·5 - 4·5 Mn ·4 - ·7 Mag 4 - 7
DURAL SHEET	L3		10·5	25	15 P	16	32	± 10	⊗ BELOW ·05" ABOVE ·04B	8 15		
HARD ALUM SHEETS	L4			9	7·5				⊗			Al 98
DURAL FORGINGS & STAMPINGS		18 B		22·5 L 17 t	13·5 Pt				⊗ FOR AIRSCREW BLADES	15 t 4 t	20	Cu 3·5 - 4·5 Mn ·4 - ·7 Mag 4 - 7 Fe ⅄ ·75
ALUM SILICON ALLOY CASTINGS		25		12					SG APPROX 2·68	7		Mn 5 Fe ·75 Si 10 - 14
MAG ALLOY FORGINGS STAMPINGS PRESSINGS		88	6	18					SG 1·82	8		Al 10 Mn 1 Zn 1·5
LIGHT ALLOY RIVETS		110		25	15	16	32	± 10	⊗ HEAT TREATED SAM AS L1			Cu 3·5 - 4·5 Mn ·4 - ·7 Mag ·4 - ·7
METAL COATED WROUGHT LIGHT ALLOY SHEET		111		24		18	32		⊗ ALCLAD Al COATED DURAL			
MAG ALLOY SHEETS		118	6	11					SUITABLE FOR WELDING	7		Al ·2 Mn 2·5 Zn ·2 Cu 2 Si ·4
MAG ALLOY SHEETS		120	6	16	7P				NOT SUITABLE FOR WELDING.	10		Al 9 Mn 1 Zn 1·5 Cu 3 Si 4
HARD ROLLED MAG ALLOY SHEETS		125		21	11P				NOT SUITABLE FOR WELDING	2		Al 9 Mn 1 Zn 1·5 Cu 3 Si 4
MAG ALLOY BARS		127	6	16 18	10 P 7·5P				UP TO 6" INCLUDING 2" OVER 2"	10 5		Al 9 Mn 1 Zn 2
MAG ALLOY BARS		129	6	20 14	12 P 6 P				UP TO 6" INCLUDING 2" OVER 2"	9 5		Al 11 Mn 1 Zn 1·5
DURAL FORGING & STAMPINGS		106										
ALUM RIVETS		148										Al ⅄ 98 Fe 1·0 Si 1·0 Fe+Si ⅄ 1·75
NAVAL BRASS BAR	B6		4·5	26					BARS UNDER ¾" DIA.	20		Cu 62 Sn 1 Zn THE REST
	B6			22					BARS ¾" & OVER	20		
PHOS BRONZE CASTINGS FOR BEARINGS	B8			10						15-4		Cu 85-89 Sn 10-13 P ·5-1·0
COLD DRAWN PHOS BRONZE BARS		78		30						15	55	Sn 5-7 P ·15-·27
MAG ALLOY BARS		142	6	15	8 P					2		2·5 Mn 2 Al 2 Zn ·2 Cu ·4 Si
MAG ALLOY CASTINGS		140	6	6					SG = 1·8 - 1·83	4		

reduced. Carefully carried out tests by R.A.E. indicate that when pins are tested in bearings on tubes that the limit of proportionality of stress to strain on such materials as S.1, S.2, and L.1, is reached when the apparent bearing stress is approximately the same as the ultimate tensile strength of the material.

The author suggests the following design recommendations as a result of experience :—

(1) Where a joint is subjected to alternating compression and tension loads, such as in an undercarriage attachment joint, the compressive or bearing stress on the bolt or attachment plates should be kept low because if a permanent set were to develop this would take place on two sides of a diameter of the bolt and lead to the development of *slop* with its subsequent racking and hammering effect on the structure, leading ultimately to premature collapse or failure of the joint. Now it has been mentioned previously that the design load factor represents $1\frac{1}{3}$ times the load likely to arise in reasonable circumstances and this could therefore be called *the first principle of aircraft design.* On this basis, therefore, it is suggested that a bearing stress of $1\frac{1}{3}\ f_t$ instead of $1.5\ f_t$ could safely be applied if due regard were paid to the arrangement of the joint to prevent secondary failure.

For *ties,* which take tension only, the deformation of the plate or pin takes place on one side of a diameter only, and the nature of a tie renders excessive loading of such easily discernible on inspection by the disappearance of the initial tension. Thus it seems fair to take a somewhat higher bearing stress and the values given in column (9) could be used with confidence, *i.e.,* a bearing stress of $1\frac{1}{2}\ f_t$.

Where members are connected by means of multi-pins or bolts, it is certain that all the fits will not be identical and 100 per cent. efficiency cannot be assumed. It is suggested that 80 to 90 per cent. efficiency be taken and the bearing stress given in column (9) assumed.

In the special example afforded by engine mountings, where vibration can be very pronounced, it is recommended that $f_b = 1\frac{1}{3}\ f_t$ should on no account be exceeded and, in addition, taper bolts provided to ensure the elimination of slop in the joint from the commencement.

Column (10). These values have been collected from various reliable sources and indicate the alternating stresses which the material will withstand when the reversals exceed five millions. As a rough guide the fatigue strength may be taken as $0.45\ f_t$.

Under the heading *mechanical tests* come columns (12) to (15) and it is with a view to showing their usefulness that the following notes are added. Additional information can be gathered from a recent paper read by Mr. L. W. Johnson before a joint meeting of the I.A.E. and R.Ae.S.[3] The main value of these mechanical tests is to provide standards against which material from the maker can be checked to see that it is in the best condition. This, the author believes is its primary object, but, at the same time, by comparing the minimum standard requirements of different materials which are under consideration for use in a certain component, this data can also be made a means of selecting the optimum material.

Column (12). The percentage elongation is the ultimate stretch observed in a test upon a standard test-piece measured on a 2in. parallel portion 0.564in. diameter. It is important that this definition be noted as different countries have different standards for the length and the diameter and the results are not, therefore, directly comparable. Further, it has been found that valid results are obtainable only from round bars and it is on this account that the bend test is preferable for sheet metals.

Column (13). Reduction in area is connected with elongation and the two together give an indication of what is likely to occur when a certain piece of material is stressed to its limit.

Column (14). Izod tests are the standard impact tests in this country and give a measure of the energy which can be absorbed by notched bars during rupture. One important fact to remember in connection with this test is that it has no absolute meaning. It is useful in discovering whether the heat treatment of certain alloy steels has been carried out properly and it is comparative among similar steels, but it does not follow that if two dissimilar steels are compared that the one having the higher izod figure will have the greater resistance to shock load. It is the opinion of some research workers that other tests could be substituted in which the energy necessary to cause fracture cracks to start were recorded. For the draughtsman, therefore, the izod value has, it would appear, no real practical value and it has been included for the benefit of those interested in heat treatment. It is certain, however, that if the izod value is not reached the heat treatment has not been properly carried out, and the material will be brittle.

For sheet metal it is impossible to carry out the izod test and in its place the bend test is made to serve the same purpose, indicating the ductile properties of the sheet.

Column (15). *Brinell Tests* for hardness are carried out on many of the metals and from the area of the spherical surface of the impression caused by a certain definite load a hardness number is obtained (Brinell No. = PKgrams/A sq. mms.). There are several modifications of this hardness test which are now coming into general use and each is designed so as to have particular advantages. To give one example the Firth Hardmeter finds a useful application in testing small finished parts where the impression made is so small as to cause no detriment to the part tested.

Tables are published which enable one to convert the various hardness numbers to the tensile strength of the material. For the draughtsman, therefore, this column is not of direct value and is of interest particularly to those who are employed on mechanical testing.

Column (16) gives the chemical composition of the various materials. This is useful for gauging the relative properties of materials, *e.g.*, ordinary and non-corrosive steels. Another use is that it affords a person not familiar with all the specifications a rapid means of comparing materials of similar chemical composition.

V. The Choice of Materials for Design Purposes to Give Maximum Efficiency

Just as the general lay-out of an aircraft is, at the best, a compromise, due regard having been paid to all the conflicting desirable features, so with the choice of materials, at its best, it constitutes a compromise limited by such factors as :—

(1) Cost.
(2) Machinability.
(3) Ease of obtaining supplies.
(4) General lightness of construction.
(5) Reliability, and resistance to corrosion.
(6) Heat treatment needed.
(7) Physical limitations of the material.
(8) Utilisation of past experience, jigs, tools, etc.
(9) The maintenance of a reasonable size of material stores.

Due regard has to be paid, subconsciously, of course, to these factors, and if aircraft are to be regarded as a true commercial commodity, it is at once obvious that it is possible that the best material cannot always be employed if the stores of a firm are to be kept of reasonable dimensions. The author believes in the utilisation of the results of the latest research and the try-out of all materials, but if production is anticipated, then often some will be debarred

from embodiment in the projected standard type by virtue of such factors as (1), (3), (5) and (8) above. The task of choosing the best material, therefore, seems at first sight rather formidable, yet it has to be faced and solved. Some suggestions are made, therefore, with a view to making this choice more systematic and the enquiring reader is referred to an excellent paper by Dr. W. H. Hatfield[4] for further information on this subject.

The tendency of modern design is to use either high tensile steel for all structural parts of an aeroplane or else use duralumin, and in some cases a combination of both.

(From the outset, the author is of the opinion that the ultra-light alloys of magnesium can be ruled out for commercial aircraft on the score of high cost and lack of resistance to corrosion. If, and when these two factors are removed, then their consideration will become necessary, but at the present time it is believed that they cannot compete favourably with H.T.S. or duralumin).

Duralumin certainly makes a strong appeal to the aircraft designer on account of its specific strength, *i.e.*, its strength/weight ratio as compared with the various steels at one's disposal. The following table (4) is of interest as a comparison of three of the generally used steel tubes compared with dural tube (T.4).

TABLE IV.

Mechanical Property.	T.4. (1)	(1)/△	T.1. (2)	(2)/△	T.5. (3)	(3)/△	T.2. (4)	(4)/△
f_t	26	9.1	35	4.5	50	6.4	85	10.9 (x)
f_s	12	4.2	23	2.95	32	4.1(x)	52	6.68(x)
f_y	18	6.3	30	3.85	40	5.12	78	10 (x)
f_b	31	10.5	52.5	6.72	75	9.6	127.5	16.4 (x)
△		2.85		7.8		7.8		7.8

It will be seen at once that on a strength/weight basis ($T4$) duralumin is in all cases better than $T1$ or $T5$, but that $T2$ is better than $T4$ in all cases. This covers such uses for tubes as :—

(*a*) (f_t) Tension members f_t steel $\geqslant 71$ tons/sq. in. to be better than dural.
(*b*) (f_y) Short strut ,, f_y steel $\geqslant 49$,, ,,
(*c*) (f_s) Torsion members f_s steel $\geqslant 33$,, ,,
(*d*) (f_b) Compression lugs f_b steel $\geqslant 81$,, ,,

If bending deflection (δ) comes into account, then this is a function of Young's modulus (E) and the I of the section, *i.e.*, $\delta = 1/EI$. Assuming similar overall dimensions, then $Z \propto I$ for steel or duralumin and $M/Z = f_y$, $Z \propto 1/f_y$ or $Z_{\text{steel}} \propto 21/49$ and $\delta \propto 18/10.5 = 1.72$ and $\delta_{\text{dural}} \propto 49/30 = 1.05$.

Thus, it can be said, other things being equal, that a steel with f_y greater than 49 tons/sq. in. will be stiffer, weight for weight, than duralumin. This statement, although fundamentally correct, cannot be realised always in practice for other conflicting reasons.

If torsional deflection (θ) comes into account, then this is a function of (N) the Bulk modulus, and the polar J of the material, *i.e.*, $\theta \propto 1/NJ$. Assuming similar overall dimensions for the tubes then $T/Z_p = f_s$ $\therefore$ $f_s \propto 1/Z$ or $Z_s \propto 1/33$.

and $\theta_s \propto 12/4.05 = 2.96$ and $\theta_s \propto 33/12 = 2.75$.

From this analysis we can say that duralumin tube is better than $T1$ for torsion members where rigidity is of account and until we use steels of greater strength than $T5$ the duralumin should prove the more efficient material. Even so, duralumin can still give a good account of itself compared with H.T.S. tube, as experiments prove that as dia./thickness increases, the permissible shear stress decreases.

Recommendations for the Choice of Materials

The author has remarked previously that one can easily be too dogmatic and that all that can be hoped for is to survey as accurately as possible the materials at one's disposal and make a selection. If agreement can in some measure be achieved then the material manufacturers will know what to provide and the number of existing specifications limited, or short listed for general design.

In Tables 1, 2 and 3, those materials marked with an asterisk in the remarks column are tentatively put forward as the minimum that could be put in such a "*short list*" and their field of application is given subsequently. In order to give greater clearness, Tables 5, 6 and 7 have been prepared and the appli-

TABLE V.

STEELS.—PROPOSED SHORT LIST OF AIRCRAFT STRUCTURAL MATERIALS.

Material.	Specification. Ordinary.	Specification. Non-Corrosive.	Remarks on Application.
Mild Steel Bar	S.1=S.6	D.T.D.24	For bolts; main fittings having low stresses—as in joints under shock loading; where fatigue is likely to be a factor in design. Where a forging or stamping is required it should be called for as S.6 which is capable of heat treatment to give higher strength (then known as S.76). Rivets and split pins in the N.C. form are made from D.T.D.24 as it can be headed up without cracking, but a low carbon content should be specified.
Mild Steel Sheet	S.3	D.T.D.39	For lightly stressed plate fittings and wrapper plates which may, if necessary, be welded. S.3 need not be normalised if really impracticable. Tinned sheet steel is S.20. Mountings for accessories are to be made from S.3.
Medium High Tensile Steel Bar	S.2 S.65	S.80	For bolts; main fittings; machined shackles, parts, pins, ferrule units, sockets for T.5 (and equivalent) tubes, etc. Forgings and stampings from S.65 and 80, but heat treatment is necessary.
Medium High Tensile Steel Strip	D.T.D.100	D.T.D.60	For rolled or drawn rib sections; pressings for plate fittings, etc. The N.C. is useful for hull construction.
High Tensile Steel Strip	D.T.D.54	D.T.D.99	For highly stressed parts not liable to fatigue failure; spar sections; butt tubing; tension members.
Streamline Wires and Tie-Rods	W.3 W.8		In addition to uses for bracing structures can be used instead of cables in straight runs of control systems.

cation of these materials indicated. It is appreciated that there will certainly arise examples where it will be desirable to use some specification not in the *short list*; but it is believed that this list could meet general requirements.

The author is of the opinion that non-corrosive steels should be avoided for *general* application on land planes as there does not seem to be real justification for the added expense they would entail both in the first cost of the raw materials and in their subsequent manipulation. For seaplanes and flying boats, stainless steels are a necessity and provide that immunity from corrosion that cannot otherwise be guaranteed.

The following notes on stainless steels have been added because it is believed they will be of special interest at the present time as representative of the current development stage of this class of material.

TABLE VI.

STEEL TUBES —PROPOSED SHORT LIST OF AIRCRAFT STRUCTURAL MATERIALS.

Material..	Specification. Ordinary.	Specification. Non-Corrosive.	Remarks on Application.
Mild Steel Tube	T.21 T.1	D.T.D.97 D.T.D.102	T.1 cannot be welded as such and when annealed becomes T.21 which needs heat treatment after welding. If normalising after welding is impracticable then D.T.D.89 or 41 should be employed. With the introduction of higher tensile steel tube T.1 is gradually being used less, relatively. T.1 is useful for euler struts made of square or non-circular section, and for lightly loaded parts needing rigidity. D.T.D.97 = T.21 and D.T.D.102 = T.1. The N.C. can be obtained in non-circular sections.
Medium High Tensile Steel Tube	D.T.D.89 D.T.D.113 T.5	D.T.D.105	For welded frameworks use D.T.D.89 in all sizes above ½in. diameter and for smaller diameters use D.T.D.113. D.T.D.89 cannot be obtained in non-circular sections and should be replaced by D.T.D.113. D.T.D.89 need not be normalised after welding, if impracticable. T.5 cannot be welded or brazed and is most useful in mechanically jointed frameworks using sockets of S.2. Small tubes of T.5 can be used for tubular rivets. This class of tubing is economical for torsion members and wherever high stresses are permissible.
High Tensile Steel Tube	T.2		For axles; special members with heavy tensile or compressive stresses; for members in bending where deflection is not a deciding factor in design.

TABLE VII.

NON-FERROUS MATERIALS.—PROPOSED SHORT LIST OF AIRCRAFT STRUCTURAL MATERIALS.

Material.	Specification.	Remarks on Application.
Duralumin Bar	L.1	For fittings requiring bulk and not highly stressed; useful for distance blocks where bearing area is required. (Rivets are D.T.D.110). All parts should be anodically treated to prevent corrosion.
Dural. Sheet and Strip	L.3	For hulls and float construction; monocoque bodies; ribs; plate fittings; girders where the easier manipulation of duralumin scores over steel. Aluminium-coated dural. (alclad) is D.T.D.111 and is more resistant to corrosion than L.3.
Dural. Forgings	D.T.D.18	For forgings and stampings and propellers. Dural. stampings are to be recommended in production work on account of certain economies in weight over steel.
Dural. Tube	T.4	For lightly loaded struts in fuselages and for torsion members. Can be obtained in any section. For control sticks.
Hard Alum. Sheet. Alum. Bar. Alum. Castings	L.4 L.32	For secondary structure; general formers; cowling and for all lightly stressed parts. For petrol tanks and all lightly stressed difficult panel work.
Hard Drawn Brass Tube. Cold Drawn Phos. Bronze Tube	T.18 D.T.D.79	For special purposes only; control columns.

Non-Corrosive Steels

There are two distinct forms, the straight chrome alloy steel, which was discovered by Mr. H. Brearley, and the proprietary brands known as Anka, Staybrite and Krupp's V.2.A., which are austenitic chromium-nickel alloys and are really not true steeels at all.

The first class can be hardened and tempered and contains about 12 per cent. chromium and 1 per cent. nickel with from 0.15 per cent. to 0.35 per cent. carbon. These steels are subject to electrolytic action when placed in contact with other metals such as bronze and it is this aspect which needs attention, otherwise the stainless properties of the material can be destroyed. For example, this form of S.S. should not be polished with rouge, as this is an oxide of iron which may set up electrolytic action with subsequent corrosion if the rouge is allowed to get into the tiny pores of the surface metal. It is found that *green chromic oxide* acts as a satisfactory polishing substance. Materials coming under this class are:—S.61, 62, 80 and D.T.D. 23, 24, 39, 53, 60, 97, 102 and 105.

The second class cannot be hardened and tempered by heat treatment, but hardens up when cold-worked. Annealing is similar, in many respects, to copper and the material is quenched in water (very thin sheets are cooled in air) from a temperature of from 1,000°C.-1,200°C. Materials in this class are:—D.T.D. 42, 43 and 57. Much trouble has been found in drilling and turning and heading up rivets in these materials and the makers assure one that a great amount can be eliminated if the cut is kept continuous or if annealing is done if the cold working is excessive. The material appears unsuitable for rivets really and a stainless iron would be far preferable. Welding of this class of non-corrosive steel is not to be recommended as unless very great care is taken in the subsequent heat treatment "weld decay" sets up with disastrous effects on the properties of the material. The Air Ministry has recently issued instructions to the effect that it must not be welded for use on aircraft.

VI. Economics of Design

When investigating the economics of design there are several factors which have to be taken into account. To give them suitable grouping they may be described as:—

(1) Materials and their supply and price.
(2) Type of design (including skilled labour necessary).
(3) Manufacturing possibilities.
(4) Ease of maintenance, upkeep and repair,

but underlying all must be kept in mind, *lightness*.

1. *Materials and their supply and price.*

It is with some trepidation that the author has decided to include this section. It is included with the very best of motives and an attempt is honestly made to make a fair and reasonable survey of the present situation in the aircraft industry. It is appreciated fully that what holds good to-day need not necessarily be the case in quite a short time. The industry is very young and manufacturers of raw materials, sections and component parts alike have been handicapped in a multitude of ways which are peculiar to the industry. Standardisation has been impossible in many ways and it is only of very recent years that metal aircraft have been turned out in series. Experimental types have been the rule instead of the exception, with the result that each firm has endeavoured to try all the available materials possible with an attempt to explore all avenues of practical research.

The object of putting in this section is to review the present situation and put forward suggestions that may help certain standards to be adopted and thus effect further economies. Let us consider first the steel and duralumin groups. It is difficult to devise a simple system for comparison, but the following is put forward as a scheme which seemed to answer the purpose tolerably well.

The prices which follow are given for comparison and are believed to be representative of the cost of bar material.

TABLE VIII.

1	2	3	4	5	6	7
Material.	f_y or f_p.	$\triangle$	$f_y/\triangle$	Pence per lb.	Wts. for equal strength compared with S.2.	Comparative price for equal strength.
HTS S2	45	7.8	5.77	5	1	1
MS S1	20	7.8	2.57	3	2.25	1.35
NC S62	34	7.8	4.37	11	1.32	2.9
Dural. L1	15	2.85	5.26	21	1.09	4.6

TABLE IX.

COMPARATIVE PRICES PER FOOT OF TUBES IN QUANTITY WITH T1 AS STANDARD.

Size	S.W.G.	T.1, T.21 & D.T.D.41	T.5.	T.20.	D.T.D.89.	D.T.D.91.	D.T.D.113.	T.2.	D.T.D.97 102 & 105.	Dural. T.4.
1¼in. sq. outside	22	1.0	1.20	0.67*		1.41	1.33		6.10	0.75*
	20	0.89*	1.07	0.56*		1.25	1.18		5.70	0.88*
	17	1.0	1.20	0.67*		1.41	1.33		7.41	1.17
1¼in. o/D ...	22	0.48*	0.57*	0.31*	0.62*	0.66*		2.34	2.89	0.59*
	20	0.48*	0.57*	0.31*	0.62*	0.66*		1.87	3.22	0.70*
	17	0.54*	0.66*	0.36*	0.72*	0.77*		1.62	4.20	0.91*
1in. sq. outside	22	1.79	2.17	1.21		2.50	2.38		11.00	1.71
	20	1.79	2.17	1.21		2.50	2.38		12.34	2.0
	17	2.09	2.5	1.38		2.92	2.76		16.00	2.67
1in. o/D ...	22	1.0	1.21	0.67*	1.33	1.42		5.00	6.34	1.25
	20	1.0	1.21	0.67*	1.33	1.42		4.00	7.00	1.47
	17	1.12	1.37	0.75*	1.5	1.58		3.38	9.33	1.92

All prices are compared with 1in. o/D × 22G × T.1.

*All prices are compared with 1¼in. sq. × 22G × T.1.

A few remarks on the above materials may be of interest and the specific yield will be used as a comparison. This covers all details which are designed on the yield strength of the material (such as beams and short struts). Column 4 gives these values and we see that S2 is a little better than dural. In column 5 the prices per lb. are quoted and in column 6, calling S2 a standard, the corresponding weights of the other materials are indicated. The last column gives the relative costs of the raw materials as compared with S2. It is important that the term *raw material* be noted. See also Table 10.

Let us now consider tubular members used for struts and as prices vary for different sizes it will be useful to consider one or two representative sizes, *e.g.*, 1 in. tubes and $1\frac{1}{4}$ in. tubes which are common sizes used in fuselage construction (Table 9). Further comments on this Table seem unnecessary as the inferences to be gathered are obvious. (Prices are per foot length.)

TABLE X.

PRICES, ETC., OF SHEET AND STRIP MATERIAL.

Material.	ft.	fy or fp	Cost Pence/lb.
S.3	28	18	3^D
D.T.D.54H	75	65	12^D
N.C. D.T.D57A		50	36^D
N.C. D.T.D.42H	55	35	22^D
N.C. D.T.D.39			21^D
L.3	25	13·5	30^D

2. *Types of Design.*

It had been hoped to deal with the detail design of such parts as the wing system and fuselage construction, but as this would lead to a great extension to the paper, fuselages alone have been discussed.

Types of Fuselage Design.

Some method of fuselage classification is necessary and for convenience the following is put forward:—

1. Round tube in steel or duralumin.
2. Square tubes and squared round tubes.
3. Monocoque.

(1) The first class needs sub-dividing for the method of jointing can be achieved in various ways.

1. (*a*) Welded joints.
1. (*b*) Machined fittings.
1. (*c*) Pressings and wrapper plates.

(1) (*a*) The welded type of fuselage is well known and has proved successful on many well tried out aircraft. A medium carbon steel is used approximating to D.T.D. 89A and having a tensile yield of 25 tons per square inch. Figs. 1a and b give typical examples of this form of construction. Large frame jigs are required for holding the tubes in position during the welding of the joints, and experience is necessary to deal with such features as distortion and the procedure in jointing tubes of different gauges. When completed the frame proves quite stiff as a structure, due to its relatively stiff joints and is a permanent fixture. Fittings and attachments for accessories can be welded on to the structure easily and, on the whole, there is a great saving by eliminating much of the skilled labour of a machine shop. But of course there are certain drawbacks. The truing up of such a frame presents decidedly awkward problems and one is uncertain of

the strains introduced into the structure, unless the latest American practice is followed and the whole frame normalised in ultra-big heat treatment stoves.

(1) (*b*) *Machined fittings* have proved very popular in this country and examples are given in Figs. 2, 3, 4 and 5. There is plenty of scope possible for

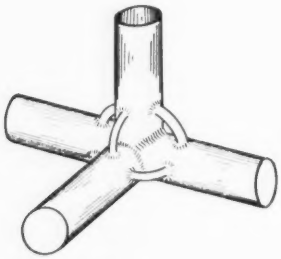


FIG. 1a

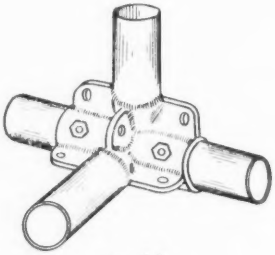


FIG. 1b

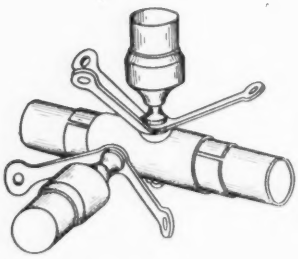


FIG. 2

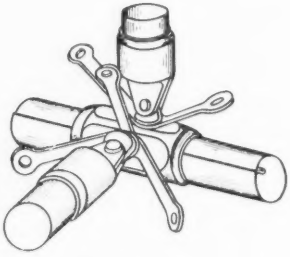


FIG. 3

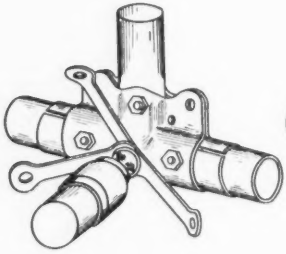


FIG. 4

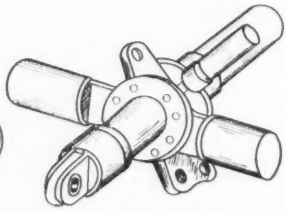


FIG. 5

ingenuity and the following gives an idea of some of the existing forms from which combinations can be made.

Pinned sockets and machined sleeves on the longerons. Standardisation becomes possible to a fair extent and continuous production, giving certain economies in manufacture.

The S2 ferrule unit has proved extremely serviceable and admits of good fits and the elimination of sweating or brazing. Dismantling can be done without damage to the structure and simple joints become possible. One serious disadvantage of ferrule units would appear to be the additional time necessary for fitting these units over such a method as tubular rivets of T5, with the ends

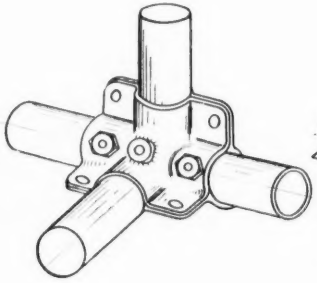


FIG: 6a

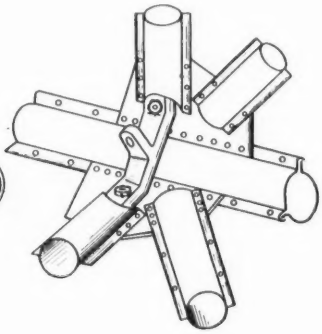


FIG: 6 b.

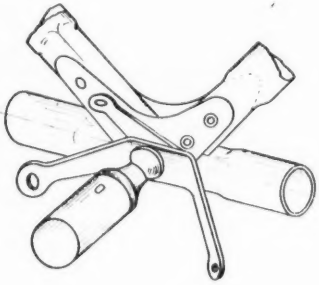


FIG 7

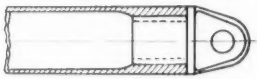


FIG 9.

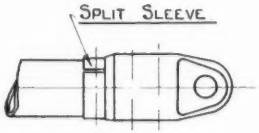


FIG: 10

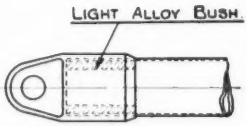


FIG: 11.

spun over. The use of machined spools for joints where many members meet has been ingeniously utilised by many firms, but with this type of joint, although offset loads are avoided, machining costs can increase very rapidly.

It is possible in this type of construction to use butt drawn tubes of HTS strip. One great merit of this type of tube is the number of economies that can

thereby be effected. For example, the gauges of the tubes can be varied to suit the loads and the lightest members in consequence utilised. There will be no delays in erection due to waiting for delivery of odd sizes from the tube manufacturers and the constructor's draw benches or rolling mills can be kept employed in producing stock and thereby helping to lessen overheads. And, finally, tubes of any length can be made in the works and the transport difficulties removed.

(1) (*c*) *Pressings and wrapper plates.*—It is possible by careful scheming and foresight to arrange for a standard pressing to act for all the joints of the rear frame of the fuselage. (See Fig. 6a). These pressings can be turned out quite cheaply in M.S. or H.T.S., and the weight of the joints can be brought to a very small amount. The butt H.T.S. tubing mentioned above can also be utilised with this scheme.

Another scheme of fuselage construction is illustrated in Fig. 6b in which strip steel is formed into suitably built-up tubes and the gusseted joints add stiffness to the structure.

(2) *Square Tubes.*—The temptation to use square tubes is very strong on account of previous experience with wooden fuselages and more so as simple joints can be utilised made from flitch plates fixed on to the tubes by means of bolts, or hollow rivets. It is not surprising, therefore, to find that this type of construction is one of the most popular in this country.

But square tubes are more costly than round, and are, as yet, more difficult to obtain in all the ranges of round, and it would seem that this consideration has led to the development of a modification of this construction in which round tubes, squared at the joints are employed. There are several advantages to be gained by this means, for the joints are smaller, the strut members approximate to taper struts, and if there is not a very sudden change from the round to the square the loss in strength should be nil. There are, naturally, certain disadvantages that have to be overcome, but these are not unsurmountable. One difficulty is to ensure that all the squared portions will line up truly when erection takes place, and a disadvantage is that big drilling jigs will be necessary for erecting the frames. The square tubular frame can be braced by tie rods, or the rigid warren truss can be adopted. By careful design it is possible to standardise to such an extent that with a few tools pressings for flitch plates are available for all sizes of aircraft likely to be contemplated. Tubular rivets of T5 with heads spun over afford a cheap and rapid means of attachment and internal support to the tubes can be provided in the form of tubular distance pieces. (See Fig. 7).

(3) *Monocoque Fuselages.*—In all probability this type of body construction is the one which makes the greatest appeal to the designer as it lends itself so admirably for the installation of all equipment and accessories. It gives the greatest "volumetric efficiency" and serves the dual purpose of both load carrying structure and fairing. It has not been used extensively in this country on the smaller types of aircraft and the appearance of the Junker "Junior" (see Fig. 8) as a competitor for world markets in the light two-seater class has made the author think it incumbent upon him to bring it up for consideration as a practical scheme of construction. On the weight basis it appears to have certain attractions, and if continuous production of some type can be guaranteed, construction can be simplified by using presses. The Junker type relies for its strength on the corrugations in thin duralumin sheet. These plates are built up on light bulkheads. In this country no corrugations have been used and the requisite strength achieved by using slightly stouter gauges of materials attached to more closely arranged bulkheads.

(3) *Manufacturing Possibilities.*—To examine this section fully would necessitate being a prophet, and with the commercial aspect of aircraft unexplored, at

the present time the author feels that all he dare do is to indicate a few commonplace facts.

As time goes on and as there becomes a real demand for commercial aircraft, it seems reasonable to suppose that manufacturers will be able to standardise a model to such an extent that the basic design can remain unchanged for a period of years, *e.g.*, the main framework of the wings and body and tail need not be radically changed. It is quite conceivable that components such as rudder bars, steering columns, adjustable seats, tail landing wheel units and undercarriage legs will be standardised. If all these could be bought as standard components, available for adoption by the whole of the industry, then their cost could, of course, be brought down tremendously to the ultimate benefit of all.

As an aeroplane is not a machine in the same way that a lathe is a machine there seems to be every chance of the elimination of 90 per cent. of the

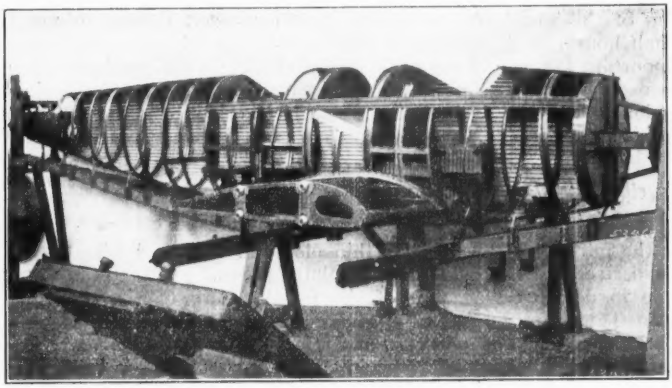


FIG. 8.
Skeleton fuselage of Junker "Junior."

machined fittings in the structure by the substitution of drop stampings and pressings. In passing it should be noted that duralumin scores over steel in drop stampings in one particular way, *i.e.*, that as there is always an excess of metal in a stamping due to getting the "draw" correct, the additional weight is less in the duralumin than in the steel.

One feature of design which seems very debatable is the policy that one should adopt in design and by that I wish to refer particularly to the desirability or not of beginning production with schemes in their final state, or going through a development stage where economies that can be effected by large scale production are adopted, when, and as that state is achieved. The problem is probably solved very satisfactorily in most cases having regard to the resources of the firm in question.

The division of construction such that skilled and quickly trained labour is available in economic proportions is one that will lead to certain compromises in the solution of aircraft construction. If great foresight is given to the matter it should be possible to keep one's staff efficiently employed and replacements should thereby be facilitated.

The unit system of construction as applied to cars, is probably the dream of many manufacturers, and with such components standardised, as are mentioned above, its realisation should be appreciably nearer, for then there will be some degree of standardisation of lay-out and components available.

4. *Ease of Maintenance and Repair.*

With the introduction of standards in components, similar to the system adopted in automobile work, ease of maintenance becomes greatly simplified, because in the event of a breakdown in remote places the time taken to get spare cables, tie-rods, wheels and tyres, tail skids or wheels, propellers and engine parts could be reduced to a minimum. If there could be a standards committee formed as soon as was possible, to formulate international standards for the parts likely to need replacement, then it is believed that a step forward would be given to aircraft development.

Maintenance is a factor which needs the greatest possible attention, for lack of means for obtaining easy maintenance will help to damn a scheme, or an aircraft, for that matter, as quickly as anything. To give an example or two, consider the cowlings proposed for some radial engines, and assess the time that would be necessary for taking one off and replacing it if an adjustment to the engine tappets were required. Or, consider an efficient aerodynamic shrouding of the wheels of an aircraft that converted the changing of a wheel from a half hour's work into half a day's work. Quick accessibility seems to be an all important factor and the provision of efficiently designed covers and panels absolute necessities. The provision of greasers is, in general, carried out, but the question of whether those greasers can be overlooked is a matter that should leave no room for doubts.

VII. Further Design Recommendations

1. *Riveted Joints in Thin Plates.*

For the purpose of these notes thin plates are denoted when 0.022 in. thick or less and riveted joints made in such plates present one of the greatest sources of trouble in design on account of the usual theory of rivet design breaking down. In Tables 11 and 12 are given the results of actual tests which the author has been able to collect from various sources and a cursory glance is sufficient to reveal the fact that the interpretation of the results is not easy.

One of the most striking results to be seen from the tables is the very high crushing stress which can be developed by relatively soft materials when used for riveting together thin plates. From a closer study of the tables it will be observed that the riveted joints have failed in most cases *by the shearing of the rivet*, or by the instability of the plates causing the plate to buckle and tear. Shearing, and not crushing of the rivet, as ordinarily understood, seems to be the reason for failure. It further seems to be indicated by the tests, that, assuming the material of the plate is at least as strong as the rivet material the bearing stress on the rivet can be neglected and attention given to the bearing stress on the plate alone. For interest, Column A has been introduced into the tables and this gives the design load that would be obtained for the riveted joint in question assuming that the above holds good. (N.B. If the shear strength of the rivet gives the lower value, then this has been inserted instead of the crushing load). The results appear to the author to be very satisfactory and lead him to suggest the following design recommendations for rivet design in thin plates:

1. Solid rivets arranged to act in single shear in thin plates will always be more efficient than rivets arranged to be in "double shear" when the ratio (rivet diameter/plate thickness) is greater than 2.0, *i.e.*, d in./t in. >2.0.

2. For solid rivets arranged to be in "double shear" in thin plates assume that they are only capable of standing up to 1.5 single shear, *i.e.*, safe load $= 1.5\, f_s.\pi d^2/4$.

3. It does not seem to be borne out by tests that the so-called "frictional grip" of the rivet heads helps in raising the strength of a small rivet in thin plates, and it should not be tacitly assumed to be a "hidden reserve." In the

TABLE II

TESTS ON RIVETED JOINTS IN SINGLE SHEAR

N°	TYPE OF RIVET	RIVET					PLATE					RESULTS OF TEST				A	REMARKS & SOURCE
		MATERIAL	SIZE	f_t	f_s	f_b	MATERIAL	THICK NESS	f_t	f_s	f_b	TYPE OF FAILURE	DEVELOPED f_s	DEVELOPED f_b	LOAD lbs	DESIGN LOAD & CONDITION	
SS1	SOLID	MS	3/32"	26	16	39	S40	015	80	48	120	RIVET IN S	19.4	95	299	247_S	MT
SS2	SOLID	DURAL	3/32"	26	16	30	L3	022"	26	16	30	RIVET IN S PLATE BEARING	19.3	64.6	298	247_S	MT
SS3	BALLOON ϕ_b .094 ϕ_b .06	MS	3/32"	26	16	39	L3	022"	26	16	30	P_T P_S	17.6	35	162	146_S	G A C 177/18/4/29
SS4	1/8 ϕ_b x .063 ϕ_b HOLLOW	HTS	1/8"	55	33	82.5	S40	013	80	48	120	P_T	157.5	120	439	439_B	G A C 324/31/5/26
SS5	SOLID	ANNEALED DURAL	1/8"	18	11	27	L3	.036"	26	16	30	P_S P_S	12.4 12.06	33.8 32.8	343 329	302_S	G A C 1095/22/4/29
SS6	BALLOON ϕ_b 127 ϕ_b 09	MS	1/8"	26	16	39	S40	022"	80	48	120	P_S			350	226_S	G A C 170/15/2/29
SS7	SOLID	MONEL	1/8"	39	28	59	L3	.036"	26	16	30	P_B	20.4 22.9	55.5 62.6	560 630	302_B ON PLATE	G A C 190/5/9/29
SS8	SOLID	MONEL	1/8"	39	23	59	L3	.048"	26	16	30	P_S	26.9 23.2	55.2 47.7	740 640	630_S	G A C 190
SS9	SOLID	MONEL	1/8"	39	23	59	SS	.036				P_S	24.5 24.5	66.7 66.7	675 675	630_S	G A C 190
SS10	SOLID	MONEL	1/8"	39	23	59	SS	.048"				P_S	26.5 26.3	54.5 53.7	730 725	630_S	G A C 190
SS11	ϕ_b 1/8" 1/ϕ_b .066" HOLLOW	SOFT SS	1/8"	46.5	28	69.7	S40	.022"	80	48	120	P_S	25.6	82	506	556_S	MT TIGHT OR LOOSELY RIVETED.
SS12	SOLID	MS	1/8"	26	16	39	SS	.024	64	38	96	P_S	25.3	103	695	439_S	MT
SS13	ϕ_b 1/8" 1/ϕ_b .066" HOLLOW	H&T SS	1/8"	60	36	90	S40	.022"	80	48	120	P_S	26.1	83.8	516	716_S	MT
SS14	SOLID	MS	5/32"	26	16	39	S40	.018"	80	48	120	P_B	18	122	779	686_S	G A C 15/3/23
SS15	SOLID	S2	5/32"	55	33	82.5	S40	.018"	80	48	120	P_B P_B	18.5 20	124 135	783 852	757_B 757_B	G A C 15/3/23
SS16	SOLID	DURAL	5/32"	26	16	39	L3	.064"	26	16	30	P_S	17.8 19.9	34 38.3	763 856	686_B	MT
SS17	SOFT I/D= HOLLOW .066"	SS	5/32"	46.5	28	69.7	S40	.022"	80	48	120	P_S & P_B	22.7	103.8	799	923_B	MT
SS18	H&T I/D= HOLLOW .066"	SS	5/32"	60	36	90	S40	.022"	80	48	120	P_S	25.6	117	900	923_B	MT
SS19	FERRULE	S2	5/16"	55	33	82.5	DTD 54H	.015" .015"	80	48	120	P_B P_B	5.9 8.9	96 145	1010 1520	1260_B 1260_B	G A C NO WASHER UNDER FERR HEAD G A C WASHER FITTED
SS20	FERRULE	S2	5/16"	55	33	82.5	DTD 54H	.03 .03	80	48	120	P_B P_B	11.0 15.0	89.6 122.5	1880 2570	2520_B 2520_B	G A C PLATE REINFD & NO WASHER G A C PLATE REINFD & WASHER FITTED
SS21	FERRULE	S2	5/16"	55	33	82.5	DTD 54H	.02" .02	80	48	120	P_B P_B	7.85 10.7	96 131	1340 1840	1680_B 1680_B	G A C G A C SIMILAR TO ABOVE 4 TESTS
SS22	FERRULE	S2	5/16"	55	33	82.5	DTD 54H	.04 .04"	80	48	120	P_B P_B	13.1 18.4	80 112.5	2240 3160	3360_B 3360_B	G A C G A C
SS23	1/ϕ_b = 3/32" HOLLOW	S1	3/16"	26	16	39	T5	.036	60	36	90	R_S	24.3	74.5	1125	740_S	G A C
SS24	1/ϕ_b = 3/32" HOLLOW	S2	3/16"	55	33	82.5	T5	.036	60	36	90	T_B & R_S	38.5	118	1780	1360_B	G A C
SS25	FERRULE	N8	3/16"	60	36	90	T5	.036	60	36	90	T_B & R_S	24.8	97.5	1475	1360_B	DEVELOPED STRESSES ASSUMING FULL AREA G A C

TABLE 12 TESTS ON RIVETED JOINTS IN DOUBLE SHEAR

No	Type Of Rivet	RIVET. Material	Size	ft	fs	fb	PLATE. Material	Thick-ness	ft	fs	fb	RESULTS OF TEST. Type Of Failure	Developed fs	Developed fb	Load lbs	"A" Design Load & Condition	REMARKS & SOURCE
DS1	SOLID	SS	3/32"	46	276	69	S40	018"	80	48	120	P_B	159	130	493	454_B	G A C 488/18/2/27
DS2	SOLID	SS	3/32"	46	276	69	S40	022"	80	48	120	R_B	181	121	563	558_B	G A C 488
DS3	SOLID	SS	3/32"	46	276	69	S40	049"	80	48	120	R_S	254	76	786	640_S	G A C 488 "THICK" PLATES SHEAR VALUE = 1·5 SINGLE SHEAR
DS4	SOLID	SS	3/32"	46	276	69	S40	062"	80	48	120	R_S	261	62	808	640_S	G A C 488 "THICK" PLATES SHEAR VALUE = 1·5 x SINGLE SHEAR
DS5	SOLID	SS	1/8"	46	276	69	S40	018"	80	48	120	P_B	131	142	716	605_B	G A C 488
DS6	SOLID	SS	1/8"	46	276	69	S40	022"	80	48	120	R_B	126	113	696	760_{SS} 740_B	HIGH fb & fs SIMULTANEOUSLY G A C 488
DS7	SOLID	SS	1/8"	46	276	69	S40	049"	80	48	120	R_S	224	90	1230	1140_S	G A C 488 "THICK" PLATES 1·5 x SINGLE SHEAR LOAD
DS8	SOLID	SS	1/8"	46	276	69	S40	062"	80	48	120	R_S	232	735	1280	1140_S	G A C 488 "THICK" PLATES 1·5 x SINGLE SHEAR LOAD
DS9	SOLID	ANNEALED COPPER	1/8"	18	11	27	L3	036"	26	16	30	R_S	112 983	618 536	616 540	303_B 452_S 455_S	G A C 1095/22/4/29 "THICK" PLATES 1·5 x SINGLE SHEAR LOAD
DS10	SOLID	MONEL	1/8"	39	23	59	L3	036"	26	16	30	P_S	184 175	100 934	1010 940	303_B 947_S	G A C 190/5/9/29 PLATE FAILURE "THICK" PLATES 1·5 SINGLE SHEAR LOAD
DS11	SOLID	MONEL	1/8"	39	23	59	L3	048"	26	16	30	P_S	212 212	866 866	1165 1165	404_B 947_S	G A C PLATE FAILURE "THICK" PLATES 1·5 SINGLE SHEAR LOAD
DS12	SOLID	MONEL	1/8"	39	23	59	SS	036"				R_S	184 200	100 1092	1010 1100	947_S	G A C "THICK" PLATES 1·5 SINGLE SHEAR LOAD
DS13	SOLID	MONEL	1/8"	39	23	59	SS	048"				R_S	225 225	916 916	1230 1230	947_S	G A C "THICK" PLATES 1·5 SINGLE SHEAR LOAD
DS14	9/D 127/b·05 BALLOON	MS	1/8"	26	16	39	S40	022"	80	48	120	R_S	854 761	376 342	2 35 2 12	225_{SS}	G A C 547/24/5/27
DS15	9/D 127/b 09 BALLOON	MS	1/8"	26	16	39	S40	011"	80	48	120	R_S	74 62	664 556	208 175	225_{SS}	G A C 547
DS16	1/D 1/16" HOLLOW	SOFT SS	1/8"	465	28	697	S40	022"	80	48	120	R_S	16	1028	634	555_{SS}	M T SS
DS17	1/D 1/16" HOLLOW	H&T SS	1/8"	60	36	90	S40	022"	80	48	120	P_B R_S	174	111 5	688	710_{SS}	M T HIGH fb & fs SIMULTANEOUSLY S S
DS18	SOLID	MS	3/32"	26	16	39	S40	018"	80	48	120	P_B	132	178	1120	870_B	G A C 15/3/23
DS19	1/D 1/16" HOLLOW	SOFT SS	3/32"	465	28	697	S40	022"	80	48	120	R_S P_B	135	1273	980	924_B	M T
DS20	1/D 1/16" HOLLOW	H&T SS	3/32"	60	36	90	S40	022"	80	48	120	P_B	158	144 8	1112	938_B	M T
DS21	SOLID	S2	3/32"	55	33	825	S40	018"	80	48	120	P_B	124	167	1050	870_B	G A C 15/3/23.
DS22	9/D 1/8" 7/b·09 BALLOON	MS	1/8"	26	16	39	DTD 100	018"	50	30	75	P_B R_S	159	847	427	377_B	G A C 262
DS23	9/D 1/8" 7/b 09 BALLOON	SS	1/8"				DTD 100	018"	50	30	75	P_B R_S	200	1065	537	377_B	G A C 262

same way small circular washers put under the heads of small rivets do not seem to have much effect in increasing the strength of the joint, although in some cases they assist in stabilising the thin plates which the rivet connects.

4. The design loads in column A are supposed to represent the ultimate failing load of the rivet and consequently it is recommended that some factor of safety be introduced into actual design work in order that riveted joints shall not develop " slop " after extensive flying service. As this applies more particularly when crushing of the plate is the criterion of design, it is suggested that f_c for the plate be assumed to be $1\frac{1}{3}\,f_t$, in order that for general cases of design the factor of safety is similar to that for other classes of joints.

5. *Hollow rivets* in thin plates appear to require special attention as there is always the possibility of an additional form of failure present, viz., the collapse of the walls of the rivet, which would lead to lower ultimate loads being developed. (The author has not had the opportunity of investigating a sufficiently large number of tests on thin walled rivets to make a really definite statement, so he personally would resort to tests before adopting new sizes of hollow rivets as standard practice.)

6. *Stainless Steel* rivets have given a considerable amount of trouble in the shops and the tests given seem to indicate that only low values of shear stress can be developed. Hollow S.S. rivets show up rather badly on test and indicate the necessity for checking representative riveted joints by actual tests.

7. It does not always follow that S.2 rivets will give higher loads than M.S. rivets as Table II, Nos. SS.14 and 15 indicate, where the criterion of strength is here the crushing of the plate. This is a point which is worth paying attention to in design as it may often lead to easier methods of manufacture.

II. *Joints in Thin Plates and Tubes*

The experience gained from tests on riveted joints can be used as a guide for designing the many forms of jointing that arise in aircraft structures, *e.g.*,

(*a*) Machined socket attachments to thin tubes;
(*b*) Flitch plate attachments to tubular members;
(*c*) Thin wiring plates; and
(*d*) Patented means of fastening.

A brief reference will now be made to these forms of joints:—

(*a*) *Machined sockets*—see Figs. 9, 10 and 11. When thin walled tubes are used care must always be taken to prevent the thin material from crinkling and buckling locally and so causing premature failing of the joint. The three methods illustrated indicate some of the possible means of avoiding such secondary failures.

Fig. 9 indicates the ideal way, but this is only possible in exceptional circumstances due to the added expense that would be entailed on small quantities.

Fig. 10 shows how one can approximate to Fig. 9 in actual practice. If the socket is external it is suggested that the split sleeve be made to go inside the socket and outside the tubular member. This will then help to stabilise the tube and if it is desired to reduce the bearing pressure a longer split sleeve will enable one to insert one or more ferrule units or bolts for this purpose. The split sleeve is generally made from the same size of tube as the member it is desired to stabilise.

If the socket is internal the sleeve should then be arranged externally, *i.e.*, fitting on the outside of the tubular member. *Fig.* 11 illustrates a development of the foregoing where it is necessary to provide ample rigidity at the joint for withstanding big side loads.

(*b*) *Flitch plates*—see Figs. 12, 13 and 14. The foregoing remarks apply essentially to round tubes and where rectangular or square section tubes are used in conjunction with flitch plates certain modifications are necessary.

Fig. 12 indicates a variation of this method where the corrugated strip is replaced by extruded aluminium blocks cut off from octagonal sections.

Fig. 13 illustrates a very satisfactory method of stabilising the walls of a flat sided tube against deformation when the bolts or ferrule units are being tightened up. The corrugated distance piece can be cut off to the requisite length from random lengths which have been made from scrap pieces of S.3. sheet suitably pressed into shape.

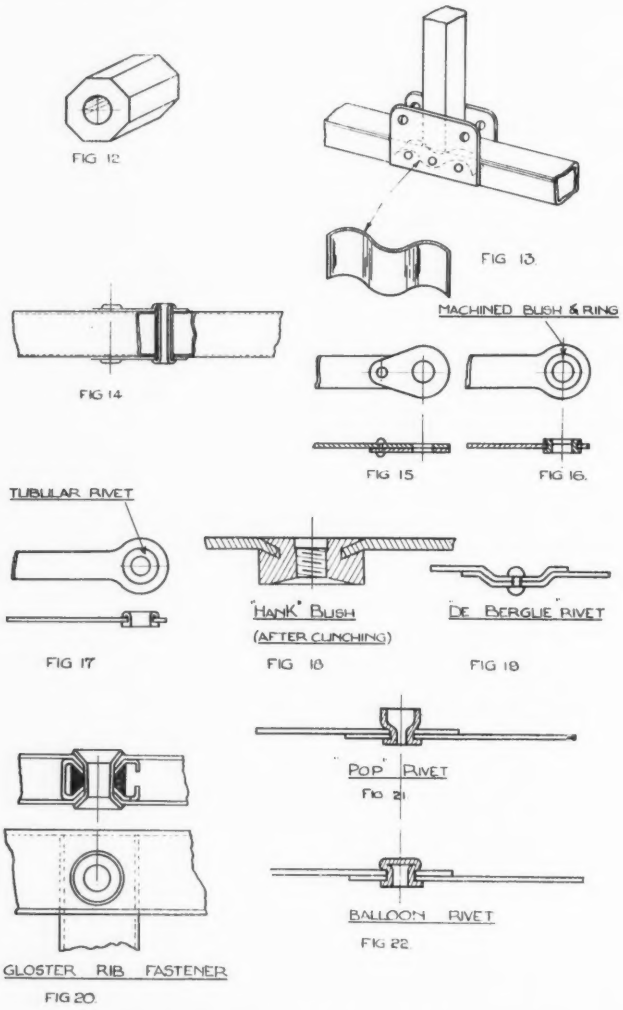


Fig 14 shows a third variation which is useful in some instances and consists essentially of a tubular distance piece over which the inner tube is riveted.

(*c*) *Thin wiring plates*—see Figs. 15, 16 and 17. A saving in the weight of detail parts is often sought by using H.T.S. fork ends and wiring plates, but unless care is taken to stabilise the thin plates failures may occur at lower loads than would normally be anticipated.

Fig. 15 illustrates a way of preventing secondary failure and the reinforcing " pad " is a means of reducing the bearing pressure on the pin in the fork end.

Figs. 16 *and* 17 show alternative methods of achieving the same result.

(*d*) *Patented and special attachments.* From time to time one comes across patented fittings which often prove invaluable for certain special purposes and among the many now available the following seem worthy of mention:—

Fig. 18. The HanK nut is a variation of the " HanK " fastener and is a neat method of spreading a load in a thin plate.

Figs. 19 *and* 20 illustrate methods of increasing the effectiveness of small diameter rivets by increasing their effective bearing area. In the latest development of the de Bergue rivet the rivet is made to fill the entire depression in the plate.

Fig. 21 illustrates the " pop " rivet which has been developed for the special purpose of fixing fittings on to tubes externally.

Fig. 22 shows the " balloon " rivet which provides an excellent fastener (easily fitted) and suitable for relatively small loads.

Conclusion

The author realises that the subject he has attempted to deal with is too wide to cover thoroughly within the limits of this paper, but the foregoing has been written with the intention of opening up a discussion on this important aspect of aircraft design that might assist the interchange of ideas and experience in detail design for the good of all concerned.

In conclusion the author would like to put on record his grateful thanks to Mr. H. P. Folland, Chief Engineer and Designer to the Gloster Aircraft Co. for the facilities so generously given him of making use of tests, and also to Mr. D. H. Emby for his valuable criticism.

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ABSTRACTS AND NOTICES

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No. 15. OCTOBER, 1930

Aircraft Design

Aeronautical Progress, 1914-1930. (R. V. Southwell, Airc. Eng., Vol. II, No. 16, June, 1930, p. 137.) (5.0/13101 Great Britain.)

The author's intimate specialist knowledge and his independence of judgment render this summary of aeronautical progress of value both as an historical appreciation and as an indication of the lines of future advance.

General Survey of German Tendency in Light Aeroplane Construction. (M. Schrenk, Z.V.D.I., Vol. LXXIV, No. 11, 15/3/30, pp. 321-330.) (5.0/13102 Germany.)

The German light aeroplane has been developed from the glider. A number of rather unorthodox types are thus being built, none of which is produced in any quantity with the exception of the all metal Junkers A.50. In the Arado L.II, pilot and passenger sit side by side in a roomy cabin with an excellent view, the engine being an inverted Argus. The control column is suspended from above, with great saving in space. The monoplane reaches 100 m.p.h. with an 80 h.p. engine on a total weight of 1,580 lbs.

Till recently most German light aeroplanes had foreign engines (Cirrus, Gypsy, Anzani and Salmson), but now have the choice of the Siemens air-cooled radial engines, 5, 7 and 9-cylinder of 80, 110 and 125 h.p. and the Argus already mentioned, on the lines of the British Gypsy.

Minimum Structural Weight of Aeroplanes. (E. Soulages, Rev. Gen. de l'Aer., No. 12, Dec., 1929, pp. 171-211.) (5.1/13103 France.)

The effect of size on structural weight is broadly considered, in particular the question of a limit of size. The results are plotted in the form of useful load and total weight against surface. A theory of structural weights is also worked out for dirigibles and the ratios of the total weights of the R.100 and L.Z.126 are compared with the calculated value with moderate agreement.

Design of Aeroplane Wings. (J. A. Newlin and G. W. Trayer, N.A.C.A., Report No. 345, June, 1930.) (5.102/13104 U.S.A.)

A wing test apparatus of the usual type is shown in a photograph. Ideal curves are established for the relation between breaking load and rib weight,

and are closely approached by the best designs. In this way certain rules are laid down for proportioning the spacing of the ribs to the depth of the spar, and for various constructional details.

Complete drawings are given of twenty-three wing ribs and of thirty-five types of truss. Test results on these are tabulated.

Metal Aircraft Construction. (Aeroplane (Supplement), Vol. XXXVIII, No. 26, 25/6/30, p. 1209.) (5.11/13105 Great Britain.)

Descriptive accounts are given of the forms and methods of construction of steel spars and metal wings, with photographs and sketches, and of methods of engine production with a number of illustrations and specifications. Two performance curves with supercharger are reproduced. Some information is given as to high grade steels, steel tubing and high duty alloys.

Use of Metals in Aircraft Construction. (H. Steudel and G. Bock, Z. Metallk., Vol. XXI, No. 7, July, 1930, pp. 213-223.) (5.11/13106 Germany.)

A comparative table is given of the principal properties of aluminium, duralumin, lautal, two types of electron, and two standard German steels. Buckling is discussed and a number of types of corrugated sheet and tube are shown in photographs. The comparative amounts of elastic strain energy are also shown from the point of view of vibrations. The applicability of welding is an important factor in weight saving. Examples of welded and riveted joints are shown in photographs. Corrosion and inflammability are also considered. Photographs of body and wing construction are given in illustration.

Methods of Riveting in Metal Aircraft Construction. (W. Pleines, L.F.F., Vol. VII, No. 1, 28/4/30, pp. 1-72, 176th Report of D.V.L.) (5.11/13107 Germany.)

The author has had practical experience of German practice in the Rohrbach Metal Aircraft Construction Co. and in the Junkers Aircraft Factory. Part I of the report gives a comprehensive summary of methods of riveting in use, particularly in German aircraft practice. Some types of punch used in hand riveting in the Junkers works are shown in sketch and photograph where the workmen's hands can reach both sides of the job. Photographs show the position of the workman and sectional sketches give examples of good and bad workmanship. Where only one side of the work is accessible, as in riveting tubes, more special methods are illustrated very fully.

Riveting by machine is discussed and photographs and diagrams of various presses in use are given. In riveting by pneumatic hammer the figure of output is given as 3,000-4,000 rivets in eight hours against 500-600 rivets by hand hammer.

Optical apparatus for the inspection of rivets in inaccessible positions is described, and photographs are given of the images of the rivet heads as seen in the inspection mirror.

The strength of different types of rivet head is tabulated both for iron and duralumin rivets. Tables of dimensions and weights are also given.

In Part II duralumin rivets in light alloy construction are considered more particularly. The relative advantages of cold and hot riveting are discussed. The stress distribution is considered and tables of strength are given for different conditions. Figures are also given from English practice.

In Section B of Part II extensive tests on the stresses in the neighbourhood of the rivet hole are described. A large number of photographs is given of specimens tested to destruction by tearing at the rivet hole and the test figures are tabulated fully.

Tests were also carried out to determine the best spacing of the rivets, and appropriate rules are laid down.

Twenty-six German references are given and one American.

Horizontal Flight of a Long Range Aeroplane. (J. Vorobeitchik, C.R., 1927, pp. 514-516.) (5.17/13108 France.)

Starting from the polar equation of the aeroplane, which is expressed in a form that takes aspect ratio into account, an integral expression is found for weight of aeroplane at a given point, and hence for the amount of petrol used up to that point. The time taken is also expressed as an integral and by an application of the calculus of variations a relation is found between distance travelled and the minimum fuel consumption. A certain mathematical precision is given to the problem, but the practical value is difficult to assess.

Propulsion by Reaction. (M. Roy, Tech. Aeron., Vol. XXI, No. 99, 15/1/30, p. 9.) (5.18/13109 France.)

An elementary hydrodynamical theory is given and the disproportionate effect of various assumptions on the calculated efficiency is exhibited numerically and graphically. It is shown that there is little scope for practical application unless possibly for aerial torpedoes at speeds of the order of 1,000 kms. per hour.

Simplified Calculations of Static Stresses in Wing Spars. (E. Plath, Z.F.M., Vol. XXI, No. 6, 28/3/30, pp. 138-141.) (5.21/13110 Germany.)

The usual formulæ are plotted in families of curves for different values of the main parameters in such a way that approximate numerical values may be read off rapidly for any combination of dimensions in the practical range. A numerical example is worked out.

The Practical Use of Logarithmic Polars for the Calculation of Aeroplane Performance. (G. Bilbault, Tech. Aeron., Vol. XXI, No. 100, 15/2/30, pp. 35-41, No. 101, 15/3/30, pp. 50-64, No. 102, 15/4/30, pp. 75-90, and No. 103, 15/5/30, pp. 100-104.) (5.3/13111 France.)

Polars are plotted on logarithmic scales, and examples show certain advantages for rapid design and performance calculations.

Aerodynamics and Hydrodynamics

Recuperation of Energy from Trailing Vortices. (M. Pris, Tech. Aer., Vol. XX, No. 98, 15/12/29, pp. 234-245, and Vol. XXI, No. 100, 15/2/30, pp. 32-34.) (5.3/13112 France.)

Diagrammatic sketches show the disposition of the recuperating blades or screws. The measured efficiencies of the latter are plotted and show sensible increases by recuperation. The author concludes that practically speaking the induced drag can only be diminished by increasing the effective aspect ratio.

Full-Scale Drag Tests on Various Parts of Fairchild (F.C.-2W2) Cabin Monoplane. (W. H. Herrnstein, N.A.C.A. Tech. Note No. 340, May, 1930.) (5.3/13113 U.S.A.)

The 20-foot research tunnel permitted tests on the central part of a full-size Fairchild cabin monoplane. The partial drags investigated were those of the tail surfaces, the engine, the landing gear, the airscrew, and the controls. The effects of adding a turtle back and of opening cabin windows were also observed. The detailed results are given in tables and in charts, and permit a rational analysis of the resistance into its components.

Wind Resistance of Automobiles. (F. W. Pawlowski, S.A.E., Vol. XXVII, No. 1, July, 1930, pp. 5-14.) (5.3/13114 U.S.A.)

An elementary theory of eddy formation round bodies of various shapes is sketched in two dimensions. Four photographs of motor cars illustrate extremes between bodies with no attempt at fairing and very completely faired bodies. Comparative curves are plotted. Methods of testing and test reduction are considered in a subsequent discussion.

Spread of Vorticity behind a Cylinder. (L. Rosenhead, Proc. Roy. Soc. A.127, No. 806, pp. 590 to 612.) (See abstract No. 14/12700.) (5.3/13115 Great Britain.)

The problem of the stability of Kármán's vortex double row is extended to the case where the cores of the vortices are of finite dimensions. The particular assumption is made that the core is of circular section and uniform vorticity, the motion outside the core being irrotational and cyclic.

In this way the problem is given a physical reality which is absent from most previous discussions.

Kelvin's treatment is reviewed and his methods are shown to be powerful and elegant and to give certain results in the simplest possible manner.

The stability of the double row is then investigated with the necessary modifications of Kármán's and Lamb's analysis.

A lengthy numerical discussion is given of the criterion for stability which is found to exist over a finite range of three-dimensional disturbances.

The Problem of Autorotation. (H. B. Irving, Airc. Eng., Vol. II, No. 16, June, 1930, p. 142.) (5.315/13116 Great Britain.)

The subject is dealt with from the point of view of aeroplane stability. The variety of the devices applied gives some indication of the complexity of the aerodynamical problems involved. A large amount of numerical data is embodied in a graphical chart, chiefly from model results, but partly also from full-scale tests.

A list of 13 British and two American references is given. No reference is made to the extensive German literature which, however, largely covers the same ground.

Flow and Force Equations for a Body Revolving in a Fluid. (A. F. Zahm, N.A.C.A. Report No. 323, March, 1930.) (5.316/13117 U.S.A.)

A development of the theory of airship hulls in curvilinear flight.

Part I gives a general method for finding the steady flow velocity round a body in plane curvilinear motion, whence the pressure is found by Bernoulli's energy principle. Integration of the pressure supplies basic formulæ for the zonal forces and moments on the revolving body.

Part II, applying this steady flow method, finds the velocity and pressure at all points of the flow inside and outside an ellipsoid and some of its limiting forms, and graphs those quantities for the latter forms. In some useful cases experimental pressures are plotted for comparison with theoretical.

Part III finds the pressure, and thence the zonal force and moment, on hulls in plane curvilinear flight.

Part IV derives general equations for the resultant fluid forces and moments on trisymmetrical bodies moving through a perfect fluid, and in some cases compares the moment values with those found for bodies moving in air.

Part V furnishes ready formulæ for potential coefficients and inertia coefficients for an ellipsoid and its limiting forms. Thence are derived tables giving numerical values of those coefficients for a comprehensive range of shapes.

Measurement of Distribution of Vortices behind Obstacles. (E. Tyler, Phil. Mag., No. 61, June, 1930, p. 1113.) (5.32/13118 Great Britain.)

Two electrically heated platinum wires 2.5 cm. long and 2.5×10^{-4} cm. diameter with constant heating currents form part of two similar electric circuits each coupled to the grid input circuit of a five-valve amplifier by means of separate primaries of a transformer. A diagram of connections gives further details. The object of the amplifier is to increase the sensitivity of the readings in determining the distribution of vortices in a stream behind an obstacle by observing the velocity fluctuations at frequencies of 1/100 sec. and upwards. Numerous numerical results obtained by this improved apparatus are tabulated and shown graphically. There is substantial agreement with the work of other experimenters, but the numerous anomalies in the hydrodynamical aspect of the subject remain unexplained.

Summary of Hydrodynamic Theory. (D. Riabouchinsky, Bull. Tech., No. 67, Feb., 1930, 72 pp.) (5.32/13119 France.)

In Chapters I and II an illustrated exposition is given of a number of solved problems in the motion of a perfect incompressible fluid. In Chapter III the question of the influence of compressibility is introduced and applied to waves of expansion. Finally, the resistance of air at high velocities is considered, particularly with reference to the flight of a bullet or projectile and a semi-empirical formula is derived which with certain adjustments fits experimental values closely.

Instability of a Fluid Heated Below. (H. Jeffreys, Proc. Cam. Phil. Soc., Vol. XXVI, Pt. 2, Apl., 1930, p. 170.) (5.32/13120 Great Britain.)

The case of an incompressible fluid has been dealt with previously by the author. Additional terms are now introduced to take account of compressibility, and to the approximations used it is found sufficient to replace the temperature gradient by the difference between temperature gradient and adiabatic gradient. This is the assumption usually made, and it is satisfactory to have a formal demonstration of its validity.

The Added Mass of Prisms Floating in Water. (A. D. Brown, E. B. Moullin and A. J. Perkins, Proc. Cam. Phil. Soc., Vol. XXVI, Pt. 2, April, 1930, p. 258.) (5.32/13121 Great Britain.)

The free simple harmonic oscillations of a floating body in a vertical plane depend on the virtual mass, *i.e.*, the mass of the body plus the effective added mass of the moving fluid. Approximate expressions are developed and the calculations are compared with experimental determinations, the latter being systematically slightly less than the former.

The Magnus Effect. (H. Blenk (reply to F. Ahlborn. See abstract No. 14/12770), Z.F.M., Vol. XXI, No. 3, 14/2/30, p. 66.) (5.32/13122 Germany.)

The rotor ship is defended as competitor of the sailing ship, not of the screw steamer.

Flight Tests of Aeroplanes. (A. Toussaint, Rev. Gen. de l'Aer., No. 12, Dec., 1926, pp. 1 to 101.) (5.322/13123 France.)

A systematic scheme of flight tests is laid down. The instruments and instrumental measurements are discussed and typical test results are plotted critically. Comparisons with model tests are also made.

Six Component Measurements on a Junkers A.35 Model at Göttingen. (H. Blenk, L.F.F., Vol. VI, No. 5, 22/3/30, pp. 156-162, 175th Report of D.V.L.) (5.323/13124 Germany.)

Dimensioned sketches of plan, front and side elevation are given, and a perspective sketch defines the system of co-ordinates used. Polars are given for wing alone and for complete model from $-20°$ to $180°$, for different elevator settings and for model without carriage.

Yawing moments are given against angle of yaw for different settings of rudder elevator and ailerons.

The model tests were made without airscrew; measurements with airscrew will follow.

The Best Bracing Point for Monoplane Wing Spars. (R. Vogt, Z.F.M., Vol. XXI, No. 2, 28/1/30, pp. 29-35.) (5.337/13125 Germany.)

Elementary expressions are found for the fibre stresses arising from bending moments, shearing forces and axial loads, for a set of five different bracing points. The total fibre stress is found by addition and plotted, to determine the minimum graphically.

The built-in monoplane spar shows little advantage over the pivoted spar.

The biplane has an advantage of about 16 per cent. in weight of spar and of bracing members. The best point of attachment appears to be at about 60 per cent. of the half span from the centre line, almost independently of the type of construction.

Note on the Wings of Gliding Birds. (G. T. Walker, Jrnl. Roy. Aer. Soc., Vol. XXXIV, No. 234, June, 1930, p. 495.) (5.37/13126 Great Britain.)

Ten sketches are given of the wings of vultures in flight.

Airscrews

Experiments on Airscrews in an Oblique Stream. (O. Flachsbart and G. Krober, Z.F.M., Vol. XX, No. 23, 14/12/29, pp. 605-614.) (5.42/13127 Germany.)

Two models were tested, one with constant chord pitch 0.5, the other with pitch, constant over the outer part of the blade, 0.2.

Details of the driving motor and of the mounting in the wind channel are given.

Two systems of axes are defined diagrammatically, one fixed with respect to the relative wind, the other with respect to the airscrew axis.

There are three coefficients of force, three of moment for each system, twelve coefficients in all. There are two independent variables, λ = relative wind/tip speed and α = incidence of the axis to wind. The twelve coefficients as determined experimentally are plotted with respect to α for different constant values of λ, and with respect to λ for different constant values of α.

The results are exhibited graphically in 20 charts, each showing a family of curves. Generally speaking, up to $15°$ axial inclination there is a comparatively small change in the axial thrust and moment, but appreciable side forces and moments come into existence.

Above $15°$ axial incidence the curves become heavily distorted.

The same remarks apply to the efficiency, which is shown in four separate charts. A preliminary chart exhibits the effect of the mounting which is comparable with the effects of $15°$ axial incidence.

The whole series gives information of great practical importance.

Resonance Vibrations in Airscrews. (F. Liebers, L.F.F., Vol. VII, No. 3, 16/5/30, pp. 137-152, 182nd Report of the D.V.L.) (5.461/13128 Germany.)

The author surveys every possible source of airscrew vibrations in resonance and concludes that irregular engine impulses are the only serious factor.

Air forces set up by vibration are of little importance. Their frequency is much larger than the frequency of rotation, so that the danger of resonance cannot arise from this source.

Modes of vibration of an airscrew are considered and it is found that the bending stiffness, the diameter of the hub and the inertia forces of rotation are the numerically important factors.

The frequency of the bending oscillations of an airscrew blade under the influence of rotational inertia forces appears to be of the same order as the engine frequency and is determined by Rayleigh's principle of the minimum natural frequency of an elastic system. This gives an upper limit.

Another rule for the frequencies of an elastic system under several systems of forces (in the present case elastic forces and inertia forces) yields a lower limit.

The upper and lower limits are so close as to determine the bending frequency under rotational inertia forces with sufficient accuracy for practical purposes.

A simple formula involving only the angular velocity of the airscrew, the natural period at standstill and the ratio of hub radius to blade length gives the natural period of bending oscillations in rotation to a sufficient approximation, and in a still simpler form gives a lower limit. The latter formula is valid for a wide range of types of blade and mounting.

In particular it appears from the formula that a relatively large hub diameter increases the natural period, as is desirable. A number of numerical examples are worked out and the results are exhibited graphically.

Material for Airscrews. (F. Seewald, Z. Metallk., Vol. XXI, No. 7, July, 1930, pp. 227-230.) (5.49/13129 Germany.)

The application of metal to the construction of airscrew blades is discussed and illustrated by six photographs of blades in steel and light alloys.

Undercarriages, Etc.

Design and Tests of Wheels and Shock Absorbers for Landing Carriages. (H. Landwerlin and L. Suard, Bull. Tech., No. 65, Jan., 1930, 33 pp.) (5.51/13130 France.)

The forces on the landing carriage transmitted from the point of contact of the wheels to the aircraft are discussed systematically and the results of static tests of separate parts are plotted and tabulated. The mechanical details are also tabulated. The systematic design of a range of wheels is considered, in particular the stresses on the wheel and the overhang of the axle. The qualities of pneumatic wheels and shock absorbers are discussed mathematically and experimentally.

Oleo Pneumatic Shock Absorber for Aeroplanes. (Engineering, Vol. CXXIX, No. 3357, 16/5/30, p. 647.) (5.51/13131 Great Britain.)

General arrangement and load deflection diagrams are given, showing an increase of the total strut load from $2\frac{1}{2}$ times to $3\frac{3}{4}$ times normal load. A working pressure of 850 lbs. per sq. in. is given, requiring to be pumped up at intervals of six months. The weights are not stated.

Shock Tests on Rubber Undercarriage Shock Absorbers. (Z.F.M., Vol. XXI, No. 6, 28/3/30, pp. 133-137.) (5.51/13132 Germany.)

Shock tests were set up in which the maximum load was applied in a very short time. In comparison with ordinary slow loading tests the maximum stresses were from 10 to 20 per cent. greater.

The stress-strain diagrams were complicated by surface friction.

A number of hysteresis loops are reproduced and a comparatively simple formula is given which relates the time of impulsive loading to the maximum stress.

Wires, Cords and Ropes in Aircraft Construction. (M. Abraham, L.F.F., Vol. VII, No. 2, 6/5/30, pp. 73-136.) (5.54/13133 Germany.)

General rigging diagrams are used to indicate every position in an aeroplane in which tension members may be used and in which control wires may be fitted.

Photographs illustrate nearly every kind of wire, cable, turnbuckle, eyelet, etc., in common use, and testing apparatus of various types.

The results of tests are given in tables and graphs and cover a wide range of English, American and particularly German practice.

The effects of corrosion are serious and in some cases the uncertainty arising from the use of tension members is to be avoided by employing other elements of construction.

The present paper contributes to rational design with a reliable load factor.

Brakes and Tail Skids for Large Aeroplanes. (Luftfahrt, Vol. XXXIV, No. 3, March, 1930, p. 76.) (5.55/13134 Germany.)

The damage done by tail skids to aerodrome surfaces has led to investigation by the D.V.L. and to their production of a new type of skid in conjunction with a compressed air brake on the wheels of the main carriage. Specification of the compressed air brake apparatus is given, accompanied by a diagrammatic sketch and three photographs. One photograph shows that the tail skid is naturally of a low resistance type, while another shows the skid replaced by a pivoting wheel. Details of weights are given.

Wheel Brakes. (Luftwacht, No. 4, April, 1930, pp. 176-182.) (5.55/13135 Germany.)

Details are given with photographs and diagrams of the Lockhead, Ford, and Sikorsky hydraulic brakes, and the Palmer and Knorr compressed air brakes.

Buckling Tests on Thin Struts with Fairing. (H. Hertel, L.F.F., Vol. VIII, No. 1, pp. 1-17, 24/5/30.) (5.56/13136 Germany.)

The distribution of stresses between strut and fairing is investigated mathematically and a simple expression is found for the combined strength.

Various types of fairing are shown in sketches, and tests on fairing alone and on the complete strut were carried out both for bending and buckling. Six tubular steel struts without fairing were tested for both bending and buckling. Component parts of the fairings were tested separately.

The arrangement of the apparatus for the buckling tests is shown in diagrams and in a photograph. The effects of friction in the end pins is discussed mathematically and in favourable cases may render the pin joint equivalent to a fixed joint. Numerous determinations of deflections and of buckling loads are embodied in tables and in fifty charts, in some cases for five different strut lengths.

Riveting the fairing to the strut at one point only may reduce the strength by local failure. Packing pieces at one-third and two-thirds of the length and

at the ends were sufficient to distribute the buckling load between strut and fairing.

For sheet metal above 0.5 mm. thick in the fairing, the agreement between calculation and test values was good.

Discontinuities in the length of the fairing diminished its stiffening effect to a small fraction of the original value.

Buckling and Bending Strength of Struts with Hollow Sections. (O. Steinitz, Z.F.M., Vol. XXI, No. 3, 14/2/30, pp. 57 to 60.) (5.56/13137 Germany.)

The simple formula for a section bounded by concentric circles is modified by the introduction of empirical coefficients. It is stated that the modified formula gives rapid approximate estimation of the modulus of certain types of hollow sections with sufficient accuracy for practical purposes.

Test Methods for Resistance of Solid Rubber Tyres to Shock. (E. Marquard, Tech. Mech. Therm., Vol. I, No. 6, June, 1930, pp. 209-218.) (5.57/13138 Germany.)

Three grades of hardness are arbitrarily qualified as soft, hard and very hard, and are represented diagrammatically by comparative stress strain diagrams, the maximum strain energy being approximately equal.

The pendulum test apparatus and the mounting of the specimens are fully described and elementary formulæ of reduction are worked out.

The test results under different pendulum impacts are plotted.

Gliding

Motorless Flight. (Aviation, Vol. XXVIII, No. 19, 10/5/30.) (5.8/13139 U.S.A.)

P. 949. At San Diego, Calif., J. Barstow, on a Bowlus glider, achieved an unofficial record by soaring for 15 hr. 13 min., attaining an altitude of 1,000 feet.

P. 951. At a glider meeting near New York, the longest flight was one of 44 seconds by W. H. Bowlus, compared with his own record of nine hours. A few details are given of the entries and methods of starting.

Gliding Expedition of the Rhön-Rossittengesellschaft Society to the Rax-Alpe, Austria, Jan.-Feb., 1929. (Report by R. Kronfeld and Dr. W. Kühnert, Z.F.M., Vol. XXI, No. 4, 28/2/30, pp. 100-108.) (5.8/13140 Germany.)

Photographs of the mountainous district and a contour map with contours at every 100 metres from 500 m. to 2,000 m. indicate the nature of the country.

The routes followed are shown in plan on the contour map and as far as possible in perspective on the photograph. Sketches are added showing the approximate flow in the neighbourhood of the mountain side. The configuration of the flow set up by secondary eddies could not be anticipated. A barogram records a flight reaching 3,200 m.

Remarks on Dynamical Gliding. (L. Prandtl, Z.F.M., Vol. XXI, No. 5, 14/3/30, p. 116.) (5.8/13141 Germany.)

A brief discussion is given of the possibility of the employment of a pulsating wind as a source of sufficient energy for gliding.

Technical Report of the Tenth Gliding Competition at the Wasserkuppe in Rhön, 1929. (A. Lippisch, Z.F.M., Vol. XXI, No. 4, 28/2/30, pp. 92-98.) (5.8/13142 Germany.)

A table gives the principal dimensions and weights of eighteen types of glider taking part in the competition.

Photographs and dimensioned sketches of seven gliders are given.

Formulæ of reduction are given to compare the performance.

Regulations for Gliders. (Aviation, Vol. XXVIII, No. 25, 21/6/30, p. 1226.) (5.8/13143 U.S.A.)

A brief summary is given of regulations issued by the Department of Commerce to bring gliders within the scope of airworthiness certificates. No new regulations are laid down.

Acoustics

Analysis of Measurement of Noise Emitted by Machinery. (B. A. G. Churcher and A. J. King, Jrnl. I.E.E., Vol. LXVIII, No. 397, Jan., 1930, p. 97.) (6.26/13144 Great Britain.)

Discussion of the above mentioned paper (see abstract No. 13/12343) is printed in Jrnl. I.E.E., 68/402, June, 1930, p. 780.

Oscillations of Diaphragms in Pulsating Fluids, with a Contribution to the Theory of Hearing. (W. Kucharski, Phys. Zeit., Vol. XXXI, No. 6, 15/3/30, p. 264.) (6.26/13145 Germany.)

A simplified model of the cochlea is investigated mathematically and it appears that the primary result of an incident sound wave is to cause the liquid in the labyrinth to oscillate. This oscillation produces a vibration of the basilar membrane by inertia and friction. By means of special fibres in contact with this membrane the distribution of the amplitude is measured and transmitted to the brain.

Reverberation in "Dead" Rooms. (C. F. Eyring, Bell. Tele. Lab., B.465, Apl., 1930.) (6.26/13146 U.S.A.)

When a uniform source of sound operates for a time in a closed room and is then cut off, repeated echoes maintain reverberation, which dies down in steps.

At each reflection the energy is reduced in a proportion depending on the coefficient of absorption. The reverberation ceases to produce an audible sound after an interval called the reverberation time.

In Sabine's formula the reverberation time is proportional to the volume of the room divided by the coefficient of absorption; with a factor depending only on the shape of the room. A more general expression is devised here, whereby each element of surface and its absorbing power is considered separately.

It is applied to sphere, circular cylinder and cube, and particular forms of the expressions are found for these cases.

For more complicated cases, the appropriate expression may be built up by suitable averaging and summing. Graphical examples are given of the time rate of reduction of intensity calculated for different coefficients of absorption, and comparison is made with the simple formula.

The arrangement of connections in the valve amplifier microphonic apparatus used, is exhibited in a diagram, and a typical set of readings is given graphically.

As an example of numerical applications, reverberation times and coefficients of absorption are calculated by Sabine's formula and by the new formula and show a reduction in reverberation time of roughly 50 per cent. over the usual

concert range. This is of considerable importance in predetermining the extent and cost of absorbing material required to obtain a specified reverberation time.

Law of Stifling of Sound by Curtains and Cushions. (J. Larmor, Proc. Cam. Phil. Soc., Vol. XXVI, Pt. 2, April, 1930, p. 231.) (6.265/13147 Great Britain.)

Critical comment is made on the result obtained by the U.S. Bureau of Standards that the relative absorption of the energy of sound waves by a curtain is independent of the incidence, following Green, Rayleigh and Kelvin. An expression is formed for the frictional loss of energy due to the uncompensated tangential step at the inter-face between two fluids, and is found to be negligible. Consideration is extended to a train of sound waves incident obliquely on a porous surface, and the stifling of sound is found to increase with the obliquity, being doubled at 60° incidence.

Navigational Instruments, Etc.

The Gyrorector. (L'Aerophile, Vol. XXXVIII, Nos. 1/2, Jan., 1930, p. 16.) (6.32/13148 France.)

A brief description with a photograph and diagrams of dial readings is given. The indication is given by the difference between a pendulum indicating the apparent vertical and the gyroscope giving the artificial horizon.

It is stated that the apparatus was used with success in the flight from Paris to Manchuria.

Elastic After-Effects, Elastic Hysteresis and Temperature Compensation in Aneroid Capsules. (L. Scriba, L.F.F., Vol. V, No. 3, p. 107-136.) (6.33/13149 Germany.)

The object of the investigations is purely practical, but various theories of hysteresis are discussed, and Prandtl's model for illustrating the molecular basis of hysteresis is reproduced with the object of throwing light on the observed facts.

Three types of test apparatus were constructed:—

1. An apparatus for the mechanical tests of capsules.
2. An optical apparatus for the same purpose, and
3. An optical apparatus for testing flat plates.

The elastic after-effects were found to depend upon the time of loading and to agree with the theory of Bennewitz for small loads; but for higher loads the observed value was less than the calculated value.

The width of the hysteresis loop increases more rapidly than in proportion to the temperature. A new type of temperature compensation was devised depending on the differential expansion of the cylinder and the end plates of the capsule. Finally, a new instrument has been designed with satisfactory elastic and thermal properties in which the cylindrical body is very stiff and the elastic forces are supplied by a special form of the end plates.

Eighteen references are given.

A Method of Measuring Turbulence in the Atmosphere. (E. Huguenard, A. Magnan and A. Planiol, C.R., Vol. CXC, No. 24, 16/6/30, pp. 1437-1439.) (6.382/13150 France).

The instantaneous velocity of the wind and the angle made with the mean direction are recorded by a hot wire anemometer and analysis of the curves determines the turbulence, defined as the apparent motion of the air to an observer travelling with mean velocity. Observed periodic motions are accounted for by the existence of large vortices.

Engine Instruments, Etc.

Investigation of Flow in Floating Disc Flow Meters. (G. Ruppel and K. J. Umpfenbach, Tech. Mech. Therm., Vol. I, No. 6, June, 1930, pp. 225-233.) (6.51/13151 Germany.)

PART I.—The disc is mounted axially in a truncated cone, and is carried upwards by the flow to a position of equilibrium. The various positions are calibrated against the flow.

Five photographs show two-dimensional formation of eddies at different flow speeds.

PART II.—The measurement of viscosity of oils and of water is discussed.

Rapidly Fluctuating Pressures Measured Electrically by Indicator Combined with Sparking Plug. (E. J. Martin and D. F. Caris, Autom. Ind., Vol. LXII, No. 7, 15/2/30, p. 230.) (6.57/13152 U.S.A.)

The requirements of an internal combustion engine indicator are ability to withstand high engine temperatures, small mass in the indicating mechanism, simple linkages, and dead-beat reading. Sectional drawings, photographs and description are given of an indicator designed to meet these requirements. Photographic records are given of the calibration curve, and of imposed simple harmonic pressures up to 30 cycles per second, 1,800 r.p.m. Further photographs show actual records, which bring out detonation, pressure oscillations, the effect of a connecting tube, and other phenomena. Records were also taken of low pressure variations such as occurred in the intake manifold.

It appears that considerable difficulties of recording at high frequency still remain to be overcome, particularly the provision of a suitable oscillograph.

New Types of Sensitive Silica Manometers. (B. Lockspeiser, J. Sc. Insts., Vol. VII, No. 5, May, 1930, pp. 145-151.) (6.57/13153 Great Britain.)

The materials used are silica rod, tube, and plate. A Bourdon type of elastic control is obtained by blowing a spherical bulb at the end of a tube, collapsing it along an axis, piercing the surface of internal contact and cutting and sealing the annulus thus formed. A diaphragm type of elastic control is obtained by blowing a spherical bulb at the end of a tube and collapsing the hemisphere remote from the tube to a more or less plane diaphragm.

Details of working up the necessary indicating attachments are given. The Bourdon type gives a nearly linear scale. The range is limited by the strength of the cut annulus to about 30 or 40 cm. of water. The diaphragm type gives a logarithmic scale with a probable error up to 30 mm. of water of about 1/1400, and withstands pressures up to an atmosphere.

The whole elastic structure being of fused silica there is no hysteresis error.

Electric Pressure Gauges. (H. Gerdien, Z.F.M., Vol. XXII, No. 2, Feb., 1930, p. 68.) (6.57/13154 Germany.)

The gauge depends on the variation of electrical capacity in a high frequency circuit. Types of gauges for measuring high pressure or tension such as occur in presses and rolling mills are described as well as a model for measuring the torque transmitted through a shaft. The gauges undergo small inertia force on account of the small displacements required. Pressure variations during 1/1000 sec. are easily recorded. A bibliography is given.

Indication of Rapidly Changing Pressures by Means of Resonance Curves. (K. Schnauffer, L.F.F., Vol. VI, Part 4, 14/2/30, pp. 126-136, 102nd Report of the D.V.L.) (6.59/13155 Germany.)

A description is given of an electrical pressure indicator apparatus in conjunction with an amplifying set. Diagrams of two alternative arrangements are given.

The actual pressures are measured by a Geber condenser with a moveable elastic plate connected to a pressure diaphragm. The capacity of the condenser is accordingly altered by the pressure. A discussion is given on the adjustment of the apparatus and the sources of error. A large number of diagrams is reproduced and interpretations are given of their peculiarities.

The question of calibration raises the fundamental difficulty of all such methods. An example of calibration curves is given graphically, and some of the errors arising are discussed numerically. Further developments of the apparatus are described and a modified instrument gives direct proportionality between pressure and displacement. Twenty-four indicator oscillograms are reproduced, with interpretations of their peculiarities. It does not appear that any final solution of the principal difficulties has been reached, but there is no doubt that these instruments are capable of giving much valuable information on the pressure changes in the cylinder.

A list of thirteen references is given.

Optics

Penetration of Light through Fog. (S. H. Anderson, Aviation, Vol. XXVIII, No. 19, 10/5/30, p. 931.) (6.61/13156 U.S.A.)

The article is of interest in that the tests were carried out in artificial fogs at the Wright Field Laboratory. The method of producing artificial fogs is discussed and a table gives the coefficient of absorption at different parts of the spectrum. Graphical charts are given, showing the percentage transmission in comparison with deep red light both of shorter wave colours and of infra-red rays.

The results are considered incomplete, and an appreciation of the method should await further experiment.

Scattering of Light. (G. F. A. Stutz, J. Franklin Inst., Vol. CCX, No. 1, July, 1930, pp. 67-86.) (6.61/13157 U.S.A.)

An experimental verification is made of Rayleigh's theory of scattering, using zinc-oxide in suspension in water. The diameters of the particles varied from 0.135 to 1.23 microns. The distribution of the scattered light for different wave lengths and the depolarisation were measured and tabulated. Sketches and photographs of the apparatus are given.

Improvement of Nocturnal Vision by Telescopes. (F. Lohle, Zeit. Instrum., 49, Dec., 1929, p. 595.) (5.71/13158 Germany.)

Improvement in vision does not increase with magnification but depends on the loss of light by absorption on reflection, as well as on the amount of light entering the pupil. A Galilean telescope gives better results than prismatic glasses.

Miscellaneous Instruments, Etc.

Portable Vibrograph. (Instrument World, Aug., 1930, p. 91.) (6.72/13159 Great Britain.)

This instrument is designed for making spot tests of high period vibrations and can be applied to a vibrating surface in any position, horizontal or vertical. The vibrations are conveyed by a toe on the instrument and transmitted through a series of levers to a fine stylus moving over a celluloid film. An independent time record is traced on the film by a second stylus.

The Free and Forced Symmetrical Oscillations of Thin Bars, Circular Diaphragms and Annuli. (A. G. Warren, Phil. Mag., Vol. IX, No. 60, May, 1930, p. 881.) (6.73/13160 Great Britain.)

A number of applications of elastic theory are worked out within the scope of the article. The form of the solutions and the numerical relations given graphically have applications in design involving vibrating reeds and discs.

Stability and Control

The Art of Flying Landplanes and Seaplanes. (N. Macmillan, Jrnl. R. Aer. Soc., Vol. XXXIV, No. 232, p. 305.) (7.0/13161 Great Britain.)

This paper gives the pilot's point of view in applying the qualities of an aeroplane as determined by systematic test flights to carry out specific military or commercial purposes. The polar diagram showing gliding angles and speeds from an inverted stalled flight through inverted flight and nose-dive to normal flight and stalling speed is instructive.

Spin in Aeroplanes. (R. Institution Lecture, H. E. Wimperis, Engineering, Vol. CXXIX, No. 3358, 23/5/30, p. 674.) (7.14/13162 Great Britain.)

A survey is given of the causes and available remedies. The uncertainty of full-scale experiments and the incomplete representation of effects by model experiments leaves a number of essential factors indeterminate, so that relative facts cannot be disentangled. With modern high speed aeroplanes such high speeds of spin might be obtained that the gyroscopic couples might overcome aerodynamic controls exercised by the pilot. Kinematic records taken from the ground and properly interpreted might give more precision to full-scale experiments.

Mathematical Investigation of Spin. (Fr. Haus, Rev. Gen. de l'Aer., No. 13, Dec., 1929, pp. 103-170.) (7.14/13163 France.)

The author summarises the dynamical principles involved and forms the equations and their solutions subject to the usual simplifications. The work follows the lines of recent reports and memoranda.

Flight Test Determination of Longitudinal Stability. (H. Blenk, L.F.F., Vol. VI, No. 5, 22/3/30, pp. 151-155, 174th Report of D.V.L.) (7.21/13164 Germany.)

A weight sliding fore and aft and a water tank in the tail enabled the position of the c.g. to be varied in a known manner. The elevator position and the dynamic pressure were recorded, and calibration curves and specimen records are reproduced.

The rudder displacements required for steady flight at given throttle are plotted against horizontal flight speed, for different positions of the c.g. The observed points lie smoothly on curves. The coefficient of normal forces on the tail surface is plotted against speed and the points are considerably scattered, but

the mean values are satisfactory. The curve of the static moment of stability shows that it diminishes as the c.g. moves aft, and as the throttle opens, the latter on account of the increase in the airscrew blast.

Comparison with Göttingen model results was considered satisfactory.

Stability of Aeroplanes. (R. Pris, Rev. Gen. de l'Aer., No. 11, Nov., 1929, pp. 25-80.) (7.21/13165 France.)

The mathematical theory of stability is summarised. German, English and French results are tabulated and plotted graphically and discussed.

Engine Design

Standardisation and Nomenclature of Fuels and Engines. (A. A. Herzfeld, Autom. Tech. Zeit., Vol. XXXIII, No. 17, 20/6/30, p. 428.) (8.0/13166 Germany.)

At the present world power congress standardisation of engine and fuel is recommended. The classification of engines by constant volume and constant pressure combustion is opposed and classification by type of ignition is advocated, with the nomenclature " igniter engines " and " burner engines " according as the fuel is ignited by extraneous agency (the igniter) or burns at the injection valve, like a torch.

Development of Aircraft Engines. (W. Kamm, L.F.F., Vol. VI, No. 4, 14/2/30, pp. 87-91, 156th Report of D.V.L., read at D.V.L.) (8.0/13167 Germany.)

Tables are given showing the change of the principal parameters from year to year for common types of engine, both German and of other nationalities.

The following are exhibited diagrammatically :—

Change per year of weight per h.p., mean effective pressure, mean piston speed, mean bearing pressure at maximum explosion pressure, mean bearing pressure at mean effective pressure, peripheral speed of the crank pins in the connecting rod bearings, peripheral speed of the cranks in the main bearing, load on crank pins corresponding to maximum explosion pressure, load on the crank pins corresponding to mean effective pressure.

A number of generalities on development are added.

It is considered that an 800 h.p. high performance engine (suitable for war purposes) can be adapted as a commercial aircraft engine at a cruising rating of 400 h.p.

Thermodynamical Problems in Aeronautical Research. (K. Löhner, L.F.F., Vol. VI, No. 4, 14/2/30, pp. 111-120, 160th Report of the D.V.L.) (8.1/13168 Germany.)

A brief general survey is given of the heat cycle. Reference is made to use of cooling media other than water or air. Considerable space is given to the physical properties of fuels in charts and in a table in which 86 physical coefficients are tabulated for the paraffins from hexane to duodekane, and for benzol, toluol and napthaline.

Two types of indicating apparatus are described and examples of indicator diagrams are given.

Forty-three references are given.

Test Apparatus for Research on Aircraft Engines. (W. Janson, L.F.F., Vol. VI, Pt. 4, 14/2/30, pp. 121-125, 161st Report of the D.V.L.) (8.18/13169 Germany.)

A description is given with photographs and diagrams of engine bench test

apparatus at the D.V.L. laboratory, including a rotating bench for measuring gyroscopic moments.

Water-Cooled Aero Engines. (A. J. Rowledge, J. Roy. Aer. Soc., Vol. XXXIV, No. 235, July, 1930, pp. 578-602.) (8.2/13170 Great Britain.)

The author gives a general survey of the problem of engine design, quotes some of the figures achieved so far, and anticipates the lines of future development and improvement. The discussion follows similar lines. In particular critical comments by Mr. Pye are a useful complement. The paper and discussion include crankshaft speeds, explosion pressure, temperatures, supercharging, gearing variable pitch airscrews, cooling systems, exhaust driven turbines, fuels, frontal area, torsional damper, etc.

Calculations of Torsional Oscillations in Diesel Engines. (E. Göller, Z.V.D.I., Vol. LXXIV, No. 16, 19/4/30, p. 497.) (8.22/13171 Germany.)

The inertia of the moving parts of the engine, of the flywheel, and of the driven machinery is the principal factor. The combined frequency is calculated from the partial frequencies by a standard formula given in approximate form. Two examples are worked out numerically for a six-cylinder engine.

The errors in the formulæ are plotted for different conditions, and in the worst case are 4 per cent. in defect.

Torsional Oscillations in Engines with Cylinders in Line. (A. Stieglitz, L.F.F., Vol. IV, No. 5, 24/7/29, pp. 133-158.) (8.22/13172 Germany.)

Torsional resonance is regarded as the principal cause of engine failure. The theory is discussed in a general manner and test results covering the design details of certain standard types of aero engines are used to give practical scope to theoretical results. Much light is thereby thrown on troubles arising from torsional resonance. The use of vector diagrams is introduced on analogy with the theory of electro-dynamical machines. These diagrams exhibit clearly the effect of damping in throwing the forces out of phase in such a way as to reduce their maximum numerical value.

Indicator diagrams are used to determine the pressure forces. The inertia forces are calculated in the usual manner. The inevitable simplifications are introduced into the differential equations which are formed and solved. The natural frequency of the crankshaft is determined by experiment and compared with the value calculated. Examples of critical speeds are worked out for a six-cylinder and a 12-cylinder engine. Resonance amplitudes measured from torsion diagrams are used to determine approximately the damping required. The theory of linear damping is worked out and formulæ are developed. An attempt is made to extend the results to solid friction damping. A method is developed for rapid practical calculations in the case of similar types of engine, but for new types various modifications will be required.

Recent Results on Torsional Oscillation. (A. Stieglitz, L.F.F., Vol. VI, Part 4, 14/2/30, pp. 103-110, 159th Report of the D.V.L., read at D.V.L.) (8.22/13173 Germany.)

Failures of shafts are due to the super-position of torsional oscillation loads on the steady load.

The elastic energy relations were considered and the exciting and damping forces discussed; the specific work is plotted graphically and indicates the critical points.

The influence of the order of firing requires attention, and the most favourable arrangement for a six-cylinder engine is laid down.

The effectiveness of a damping arrangement was examined and the most favourable adjustment determined.

Resonance curves are prepared from engines with and without dampers. A brief account of methods of measurement is added. A discussion follows.

Oscillations in Aircraft Power Plants. (K. Lürenbaum, L.F.F., Vol. VI, No. 4, 14/2/30, pp. 97-102, 158th Report of the D.V.L.) (8.22/13174 Germany.)

A brief summary is given of the possible vibrations in the power plant, with particular reference to resonance. Torsional vibrations receive special consideration as being the more important and dangerous. A description is given of test apparatus and in particular of special elastic couplings with rubber packing, designed for the purpose of damping any serious resonance at the critical speeds which are considered unavoidable.

Bending Oscillations of Engines. (J. Geiger, Z.V.D.I., Vol. LXXIV, No. 17, 26/4/30, pp. 542-544.) (8.22/13175 Germany.)

The side pressure of the piston on the cylinder wall subjects the engine and its foundation to periodic forces in the plane at right angles to the crankshaft, which is specially important in large Diesel engines. The resulting vibrations were recorded by the author's vibrograph, and by suitable arrangement of the order of firing and the position of the crank throws, the transverse vibration was reduced.

Torsional Vibration in Multi-Crankshafts. (A. Stodola, Z.A.M.M., Vol. IX, No. 5, Oct., 1929, pp. 349-360.) (8.22/13176 Germany.)

The vectorial method is applied to a six-cylinder Diesel engine. By suitable choice of masses concentrated on the shaft as well as by adjustment of the elastic forces, it is possible to avoid dangerous oscillation, although the frequency of the applied force agrees with one of the free frequencies of the shaft, a case of "apparent resonance" not generally considered in text books. Although this solution of the torsional oscillation problem is not generally practicable with existing engines, the question is one of considerable theoretical interest.

Angular Distortion of Crankshafts. (C. A. Norman and K. W. Stinson, Ohio State University Bulletin, No. 43, 1928, 20 pp.) (8.22/13177 U.S.A.)

The authors quote Carter's formula, which they consider a good approximation, but offer a formula of their own which they consider more accurate in some respects. The numerical values given by their formula and by Carter's are tabulated against experimental results for eleven crankshafts. The mean calculated figure is about 10 per cent. greater than the experimental figure. Extreme cases are -11 and $+28$ per cent.

Crankshaft Fractures. (Flug, No. 5, May, 1930, p. 6.) (8.22/13178 Austria.)

From experiments at Adlershof with crankshafts changes of section and the presence of oil holes reduce the fatigue strength of the finished shaft to approximately 60 per cent. of a uniform bar. As the fatigue strength is about half the ultimate tensile strength, static tests are of indirect importance. The fatigue limits should be determined under conditions approaching working conditions. The material affects the ultimate fatigue limit in an uncertain way; any high grade steel behaves satisfactorily if the design of the shaft is correct, but an increase in the surface hardening of the material raises the fatigue limits sensibly.

The Waldstein Coupling. (Z.V.D.I., Vol. LXXIV, No. 15, 12/4/30, p. 482.) (8.2205/13179 Germany.)

An arrangement of endless belts, coupling pairs of roller pins, one mounted on the driving side and one on the driven side, and kept taut by an inner system of stirrups and belt, distributes the stresses evenly over the system for the permissible range of torque, and also takes up a certain amount of eccentricity between driving side and driven side.

Recent Experiments on the Wear of Metals. (W. Fink, Z.V.D.I., Vol. LXXIV, No. 3, 18/1/30, pp. 85-87.) (8.23/13180 Germany.)

The wear of metals is largely due to oxidation brought about by intimate contact with oxygen under pressure, which continues even if the load is insufficient to cause mechanical breakdown. If air is replaced by an inert gas there is no oxidation; the friction between metal surfaces is considerably reduced and the wear is reduced to that due to the tearing off of material, which can be prevented altogether by suitable adjustment of the load.

Bearing Bronzes with the Additions of Zinc and other Metals. (R. L. Dowdell and C. E. Eggerschwiller, S.A.E., Vol. XXVII, No. 1, July, 1930, pp. 45-55.) (8.23/13181 U.S.A.)

Specifications are given of seven basic copper-tin-lead bearing bronzes, which were subjected to tests for Brinnell hardness, resistance to impact, pounding and wear.

The influence of additions of zinc, phosphorus, nickel and antimony, were investigated. In all forty alloys of which the chemical analysis is given were tested. Further specifications are given of fifty-four different bearing bronzes in common use.

Questions of lubrication are also considered.

Photographs and dimensioned sketches of test specimens with perspective drawings of three-dimensional models with ruled surfaces, indicate the results of tests. A number of micro-photographs are given.

Thick-Walled Cylinders under Pressure. (R. W. Bailey, Engineering, Vol. CXXIX, No. 3363, pp. 818-819.) (8.24/13182 Great Britain.)

The creep of the material under stresses beyond the elastic limit at a constant temperature is discussed. The discussion is extended to the cases of variable temperature distributions set up by radial transmission of heat inwards and outwards. The creep of the cylinders under internal pressure is shown to be connected with the creep of the material in shear provided the material is approximately isotropic.

Engine Cooling

The Condensation of Steam in Films and Drops. (Tech. Mech. und Therm., Vol. I, No. 2, 1930, p. 53.) (8.3/13183 Germany.)

In experiments, steam impinging on a flat plate condensed in fine drops with a heat transfer of 40,000 Kal/m^2h°C. If the plate was etched the steam condensed in a film with a heat transfer of only 5,000 Kal/m^2h°C. At the centre of the cooling water jet the transfer was 70,000 Kal/m^2h°C. for a jet velocity of 30 ft. per sec.

Coefficient of Heat Transfer from Internal Tube Walls. (A. Eagle and R. M. Ferguson, Proc. Roy. Soc., A. Vol. CXXVII, No. 806, pp. 540 to 566.) (8.3/13184 Great Britain.)

Osborne Reynolds' formula for heat transfer is modified to take into account a boundary layer of laminar flow.

Using dimensional methods for reduction of observations under different conditions, three experimental coefficients are determined and tabulated, along with three derived coefficients.

The empirical treatment is referred to as a " theory."

The soluble problem of laminar flow, referred to here as viscous flow, is briefly discussed. A diagram and description of the experimental apparatus are given.

Theory of Heat Conduction. (M. S. van Dusen, Bur. St. Jrnl. Res., Vol. IV, No. 6, June, 1930, p. 753.) (8.3/13185 U.S.A.)

The problem of heat flow where the thermometric conductivity is a function of the temperature is considered.

A new variable is introduced and the transformed equation takes the form:—

$$\nabla^2 U = 0$$

with a special form of the boundary condition.

An example is worked out in cylindrical co-ordinates.

The result may have an application in slow viscous fluid motion with variable viscosity.

Lubrication

Lubricants, German Association for Technical Material Testing. (Erdol and Teer, 6, 46-8 (1930), Chem. Abstr., Vol. XXIV, No. 11, 10/6/30, p. 2872.) (8.41/13186 U.S.A.)

The ageing of oils is entirely due to oxidation. Samples kept in a vacuum do not deteriorate. Known oxidation inhibitors were without effect. A suitable negative catalyst is being sought.

Some Notes on Oil Purification as Applied to Air Engines. (G. Manley, Flight, Vol. XXI, No. 39 (Aircraft Engineering Section), page 69, 1929.) (8.44/13187 Great Britain.)

An effective filter will remove most of the impurities found in lubricating oils in an engine. Other methods are discussed.

Fuels

New Method of Determining the Corrosive Action of Engine Fuels on a Series of Common Metals. (Wawrziniok, Autom. Tech. Zeit., Vol. XXXIII, No. 1, 10/1/30, p. 28, Vol. XXXIII, No. 2, 20/1/30, p. 58, Vol. XXXIII, No. 4, 10/2/30, p. 110.) (8.51/13188 Germany.)

The immersed samples were subjected to an oscillatory motion in the presence of air and fuel. Fuels containing alcohol were generally found to show more corrosion than ordinary petrols. In every case it was found that some of the metal had gone into solution in the fuel.

Survey of Fuel Analysis. (G. Bandte, Autom. Tech. Zeit., Vol. XXXIII, No. 17, 20/6/30, pp. 430-432.) (8.51/13189 Germany.)

Tests in the laboratory have failed to decide the suitability of a given fuel for internal combustion engines. Midgley's bouncing pin apparatus is the most convenient for direct engine tests. In its new form instead of measuring the

amount of electrolytic gas evolved by timing with a stop watch, the heat generated in the bouncing pin circuit is measured by a thermo-junction and recorded directly on a voltmeter.

Fuels and Dopes for Aircraft Engines. (A. E. Dunstan and F. B. Thole, Jrnl. R. Aer. Soc., Vol. XXXIV, No. 232, p. 329.) (8.51/13190 Great Britain.)

The physical chemical and thermal properties are defined and classified. The more elusive anti-knock value of fuels is discussed. In the discussion and reply the possibilities of replacing natural light fuel by cracked fuels was reviewed. The reduction of fire risks by using fuel of higher flash point was considered.

Some Phenomena of Gum Determinations in Motor Fuel. (E. C. Herthel and F. A. Apgar, Am. Petroleum Inst. Proc., No. 1, Sec. III, 124-32 (1930), Chem. Abstr., Vol. XXIV, No. 8, 20/4/30, p. 1967.) (8.51/13191 U.S.A.)

Gum determinations by the copper dish method, the steam oven method, and the oxygen absorption method cannot be correlated with one another, nor do they agree with storage performance tests which are affected by light and moisture. The effect of certain metal catalysts is given.

Standard Method for Determining Gum Content of Cracked Gasolines. (I. E. Bespolov, Azerbaidzhanskoe Neftyanoe Khozyaistvo, 1930, No. 1, 57-8, Chem. Abstr., Vol. XXIV, No. 8, 20/4/30, p. 1967.) (8.512/13192 Russia.)

Chemical inhibitors have been found which prevent loss of knock-rating during accelerated oxidation. Processes for the restoration of cracked petrol which has depreciated in knock-rating have been developed.

The Metal Carbonyls. (R. L. Mond, J. Soc. Chem. Ind., Vol. XLIX, No. 24, 13/6/30, p. 271 T; No. 25, 20/6/30, p. 283 T; No. 26, 27/6/30, p. 287 T.) (8.514/13193 Great Britain.)

The manufacture of nickel, iron, cobalt, molybdenum, ruthenium, chromium and tungsten carbonyls is discussed.

As an anti-knock, iron carbonyl is the most interesting and the continental fuel known as Motalin contains 0.2 per cent. in solution with ordinary petrol. The carbonyls as a possible source of a pure metal have not so far received commercial application, with the exception of the formation of the metallic mirror on the interior of thermos flasks by the decomposition of nickel carbonyl.

An extensive bibliography including a list of patents is added.

Anti-Knock Testing and Performance. (E. Bartholomew, Oil and Gas, J. 28, No. 22, 32-3, 145 (1920); *cf.* C.A. 24, 2280, Chem. Abstr., Vol. XXIV, No. 11, 10/6/30, p. 2870.) (8.514/13194 U.S.A.)

Generally speaking, increase of speed or temperature lowers the detonation of fuels containing ethyl fluid, but raises it in the case of benzol mixtures.

Stabilisation of Knock Rating, Gums and Colour of Gasoline by Chemical Inhibitors. (G. Egloff, W. F. Faragher and J. C. Morrell, Am. Petroleum Inst. Proc., No. 1, Sec. III, 112-7 (1930), Chem. Abstr., Vol. XXIV, No. 8, 20/4/30, p. 2967.) (8.514/13195 U.S.A.)

There is no definite connection between the formation of gum and the lowering of anti-knock value. Experiments were carried out with chemical inhibitors which retard gum formation during storage. Processes for the restoration of cracked petrols which have fallen off in anti-knock value during storage are described.

French Patent No. 670706, March 2nd, 1929. (E. H. Strange.) (8.514/13196 France.)

Certain compounds of iodine, including iodoaniline, are proposed as anti-detonators in proportions of the order of 1/500.

Flame Characteristics of "Pinking" and "Non-Pinking" Fuels, Part II. (G. B. Maxwell and R. V. Wheeler, Fuel, Vol. IX, No. 3, March, 1930, p. 121.) (8.514/13197 Great Britain.)

Simultaneous photographs of the flame travel and pressure rise were taken in a closed cylinder 15 in. long and 6 in. diameter. Benzine, pentane and mixtures, gaseous fuels like hydrogen, and the addition of amyl nitrite, carbon bisulphide, etc., were investigated. Previous conclusions were verified. Pinking is due to the formation of stationary waves, which are maintained by residual chemical energy, after the main flame has traversed the mixture. Turbulence destroys pinking by delaying the formation of the stationary wave. Dopes act by making the combustion continuous in the wake of the flame. Auto-ignition in front of the flame does not produce detonation.

Effect of Tetraethyl Lead, Hot Surfaces and Spark Ignition on Flame and Pressure Propagation. (M. Souders, Jr., and G. G. Brown, Ind. and Eng. Chem., No. 21, 1/12/29, p. 1261.) (8.514/13198 U.S.A.)

Tetraethyl lead vapour does not retard combustion until it is decomposed by the flame. Auto-ignition by a hot plate is prevented or delayed by the presence of decomposed tetraethyl lead.

Carburettors and Feed Systems

Altitude Control of Aeroplane Engines. (J. Pettit-Herriot, Airc. Eng., Vol. II, No. 16, June, 1930, p. 133.) (13199 Great Britain.)

An account, mainly descriptive, of the two common types of altitude control is given. These are the vacuum type and the variable jet control. Considerations are given for preferring the latter. The plant required for producing artificial altitude conditions is discussed, and a diagram is given illustrating the effect of operating the variable jet control in different ways.

The R.E.F. (l'Orange) Fuel Pump. (L. Hausfelder, Autom. Tech. Zeit., Vol. XXXII, No. 32, 20/11/29, pp. 726-728.) (8.544/13200 Germany.)

In the R.E.F. fuel pump, as in Acro and Junkers fuel pumps, delivery of fuel is governed by rotation of the fuel pump plunger. The suction valve is incorporated in the fuel plunger and the volumetric efficiency is maintained over a wide range of speed. A series of standard sizes is produced and has found considerable application.

Oil Engines

The Development of the Junker Diesel Aero Engine. (Gasterstädt Autom. Tech. Zeit., Vol. XXXIII, No. 1, 10/1/30, p. 2 (Pt. I), and No. 2, 30/1/30, p. 41 (Pt. II).) (8.59/13201 Germany.)

The Junker aero engine is an adaptation of their opposed piston commercial engine. Reduction in weight is obtained by the use of light alloys and increased speed. The crankcase housing of the 12 cylinder liners is cast in a single block in silumin. A centrifugal fan is employed for the scavenge air, turbulence being obtained by a spiral arrangement of the inlet ports; with careful dimensioning of the air passage an air pressure as low as 3 lbs. per sq. inch is sufficient, in spite of the relatively high engine speed. Two fuel pumps are used per cylinder, half load being obtained by cutting out one pump completely. Four fuel nozzles

produce the spray in the form of a thin fan. The fuel nozzles are of the open type, and accurate injection timing is ensured by placing the pump close to the nozzles. Jerk injection is employed and the pumps are governed by rotating the plungers. When running light the fuel can be diverted into the suction line. The engine pistons are oil-cooled. Difficulties were experienced with the gear drive between the two crankshafts. A special torsiongraph was designed to investigate this problem, diagrams being taken simultaneously at the four ends of the two crankshafts.

The Effect of the Size of the Pre-Ignition Chamber on the Functioning of a Two-Stage Ignition Diesel Engine. (H. Mehlig, Autom. Tech. Zeit., Vol. XXXII, No. 32, 20/11/29, p. 723, and No. 34, 10/12/30, p. 783.) (8.59/13202 Germany.)

The mathematical analysis concerns only the compression stroke, and is developed for engines of the Acro Bosch type, where the ignition chamber is placed in the piston. In practice only about one half of the calculated pressure difference between the chamber and the main cylinder is obtained. This diminution is due to heating of the air in the chamber. Machines of different size, but similar design, have similar compression curves provided the piston speed is the same.

The Diesel Engine for Vehicles from the Point of View of Economy. (Wawrziniok, Autom. Tech. Zeit., Vol. XXXIII, No. 17, 20/6/30, pp. 416-420.) (8.59/13203 Germany.)

From the tabulated performance figures of the principal continental mobile Diesel engines those using pre-ignition chambers (so called two-stage ignition) work at practically the same mean effective pressure as those with normal pressure air injection. The average weight is about two and a half times that of a carburettor engine of equal horse-power and the space occupied is considerably greater, both involving increased chassis size and weight. These drawbacks off-set the admitted saving in fuel cost.

Present Limits of Performance of Mobile Diesel Engines. (P. H. Schweitzer, Autom. Tech. Zeit., Vol. XXXIII, No. 17, 20/6/30, p. 414-416.) (8.59/13204 Germany.)

The moderate practicable speed and the limited mean effective pressure of mobile Diesel engines are the main reasons for a power/weight ratio twice that of the petrol engine. The mean effective pressure can be increased to some extent by modifying the injection nozzles and the shape of the combustion chamber. The speed can be increased only if the injection delay can be reduced, most readily by increasing the compression ratio from 14-1 to 18 or 20-1. The cost of manufacture could be kept down by careful design and mass production.

The Packard Diesel Engine. (Airc. Eng., Vol. II, No. 17, July, 1930, p. 163. See abstract No. 13/12395.) 8.59/13205 Great Britain.)

The available technical details are given with suitable comment and performance in comparison with petrol engines.

Recent Developments in Airless Injection of Fuel in Diesel Engines. (Fuel, Vol. IX, No. 3, March, 1930, p. 130.) (8.59/13206 Great Britain.)

Messrs. Sulzer have developed an injection valve fed by pressure from a hydraulic type accumulator with a wider range of size of fuel orifice and of injection pressure than the ordinary jerk pump. The pressure is recorded electrically by changes in contact resistance between the pipe line and an enveloping gauge.

1,200 h.p. Diesel Locomotive with High Air Pressure Transmission. (Witte and Wagner, Z.V.D.I., Vol. LXXIV, No. 10, 8/3/30, p. 289.) (8.59/13207 Germany.)

The M.A.M. firm has built a six-cylinder single-acting engine with solid injection and a single stage air compressor driven by an extension of the crankshaft. Water injection to the compressor limits the air temperature to about 200°C. after compression. The water is highly atomised and injected towards the end of the compression stroke through a nozzle, much as in fuel injection. The compressed air is passed through a heater receiving heat from the exhaust, where its temperature is raised to approximately 300°C., and actuates a piston engine coupled to the driving wheel.

The radiator is placed in front as in motor car practice. The control, entirely by throttling the air supply, is as flexible as for the steam locomotive. The output is 1,200 h.p. at about 450 r.p.m.

Compression Ignition Engines. (A. B. Thiemann, Ill. Flug, Vol. XI, No. 10, Oct., 1929, p. 203.) (8.59/13208 Germany.)

A review is given of the attempts made during and since the war to develop a practicable compression ignition aeroplane engine. Sectional diagrams are given of methods of injection and general arrangement and photographs of various types, including Beardmore, Great Britain; Sunbeam, Great Britain; Junkers, Germany; and Packard, U.S.A.

The Design and Development of an Automatic Injection Valve with an Annular Orifice of Varying Area. (W. F. Joachim, C. W. Hicks and H. H. Foster, N.A.C.A. Report, No. 341, March, 1930.) (8.595/13209 U.S.A.)

From author's summary:—An automatic injection valve giving a finely atomised oil spray of broad cone angle was designed with only six parts—two concentric nozzle tubes flared at one end, two body parts, and two nuts. The nozzle tubes are provided with seats at the flared ends to form an annular orifice which automatically varies in area with the injection pressure. Adjustment of the nuts determines the valve-opening pressure. High speed engine tests indicate that the time lag of auto-ignition is reduced and the efficient combustion is promoted.

Magneto E.M. Shielding

Suppressing Ignition Interference. (E. A. Robertson and L. M. Hull, S.A.E., Vol. XXVII, No. 1, July, 1930, pp. 78-86.) (8.93/13210 U.S.A.)

The question of shielding is discussed and various types of shield are illustrated by photographs.

Bomb Dropping

Transparency of the Sea from Different Heights. (G. Platania, Not. Tech. Aer., Vol. VI, No. 5, May, 1930.) (9.0/13211 Italy.)

For observation of submarine objects aircraft have certain advantages over surface vessels, not so much by reason of any greater transparency but by greater range of vision at a favourable angle. Certain measurements of the transparency of the sea were made at Capri, and the results are given in confirmation of the author's views.

Control of Bombing by Lieut.-Col. Tetu's Method. (Guyomer, Rev. F. Aer., No. 7, Feb., 1930, pp. 166-185.) (9.5/13212 France.)

An elementary mathematical account is given of the sighting methods, with diagrams illustrating the usual types of error. The use of the recording camera

for training purposes is discussed. A photograph shows twenty bombs shortly after release from the aircraft.

Materials

Ferrous Metals

Transactions of the D.V.L. Session, 17/3/30. (Z.V.D.I., Vol. LXXIV, No. 20, 17/5/30, p. 645.) (10.0/13213 Germany.)

The report of the society's activities includes:—(1) Paints, dopes, varnishes, etc.; (2) welding; (3) mechanical vibrations; (4) researches in heat transference; (5) materials; (7) wire cables; (8) timbers, etc.; and thirteen complete and twenty-four incomplete researches. Among the completed researches are the following:—

Fatigue tests on high frequency test machines.
Radio-graphic examination of loads.
Compression and bending tests with jointed struts.
Resonance of timber panels with reference to acoustics of rooms.
Crushing limit and force required in forging various metals at different temperatures.
Heat transference from tubes to highly viscous fluids.
Comparative torsional oscillation for the determination of damping.
Accurate measurements of flow coefficients over a weir.

The Addition of Nickel and Chromium to Cast Iron for Engine Cylinders. (Mahle, Autom. Tech. Zeit., Vol. XXXIII, Part 2, 10/1/30, p. 34.) (10.11/13214 Germany.)

Small additions of nickel to certain types of cast iron (between 2 and 4 per cent.) increase the surface hardness and reduce wear.

Recent Development of High Grade Steel. (P. Goerens, Z.V.D.I., Vol. LXXIV, No. 10, 8/3/30, pp. 297-302.) (10.12/13215 Germany.)

High grade alloy steels are produced by electric arc or by high frequency induction current. The initial difficulties in the manufacture of chrome nickel steels which led to extreme brittleness have been overcome by temperature control and by the addition of small quantities of molybdenum as a stabiliser. To meet the requirements of modern chemical industries the working temperatures have risen rapidly.

Crucibles will withstand temperatures of over 1,000°C. in corrosive atmospheres. The use of high pressure steam with large superheat has affected turbine blading. The increase in dimensions of electrical machinery imposes increase in size of castings and forgings; and attention to composition has overcome initial difficulties. Heat resisting properties have been obtained by the diffusion of aluminium into the surface, known as alitisation, akin to cementation of steel. Reference is made to cast or sintered tool steels of high tungsten and cobalt content.

Value of Deposited Chromium as a Corrosion Preventative. (L. Wright, Jrnl. Soc. Chem. Ind., Vol. XLIX, No. 23, 6/6/30, p. 473.) (10.15/13216 Great Britain.)

To achieve permanence on steel there must be a sound undercoat of nickel at least 1/1000th inch thick. The nickel resists corrosion and the chromium tarnish. With good technique the double coat will give reasonable protection in most circumstances but is not easy to produce with the necessary degree of adhesion. The general tendency to provide chromium plating at low cost without precautions has given the process a bad name.

Some Outdoor Tests of Protective Painting. (U. R. Evans and S. C. Britton, J. Soc. Chem. Ind., Vol. XLIX, No. 14, 4/4/30, p. 173 T.) (10.15/13217 Great Britain.)

It was found that small differences in the composition of the paint had more influence on its resistance to corrosion than differences in the nature of the steel to be protected. Freshly mixed paint with a minimum quantity of oil and thinner gives the best results. Nitro-cellulose paints give generally bad results and appear sensitive to the presence of rust on the metal before painting. Of red lead, iron oxide and graphite, the first gave generally the best results. If, however, the surface to be painted is already covered with rust the graphite paint is to be advised. The air plays a predominant part, London air being especially harmful.

Light Alloys

Strength in Shear of Thin Curved Sheets of Alclad. (G. M. Smith, N.A.C.A., Tech. Note, No. 343, June, 1930, 35 pp.) (10.21/13218 U.S.A.)

The size of the test specimens is not stated, but by counting the ¼in. rivet holes in the illustrations and allowing a pitch of 1in. the specimens appear to be about 8in. by 24in. They are mounted for the most part on frames with straight 24in. edges and curved 8in. ribs. Four different radii were adopted of approximately 4.3, 5.2, 6.2 and 6.9 inches. Four sheet gauges were used, .010, .014, .020 and .032. The method of mounting and testing is described and illustrated by sketches and photographs. The buckling shear loads are plotted against the thickness of the sheet, and give a family of curves, the buckling load increasing with the curvature of the sheet. An empirical formula is given, giving the shear stress at buckling as proportional to the thickness divided by the radius of curvature. The experimental results are plotted showing the shear stress of buckling, a function of the radius over thickness. The experimental points lie fairly well on the hyperbola indicated by the formula.

The results should be useful to designers.

Treatable Aluminium Alloys, Brinnell Hardness, Elastic Limit and Tensile Strength. (P. Melchoir, Z. Metallk., Vol. XXII, No. 5, May, 1930, pp. 175-176.) (10.2101/13219 Germany.)

Linear relations are established between the elastic limit, the ultimate tensile strength and the Brinnell hardness of treatable alloys. The experimental values are plotted and compared with the straight lines given by the linear relations. The agreement is fair.

Treatable Aluminium Alloys. (T. W. Downes, Autom. Ind., Vol. LXII, No. 25, 21/6/30, pp. 944-949.) (10.2101/13220 U.S.A.)

Remarkable improvement of certain cast alloys can be effected by heat treatment. A particular alloy showing ultimate tensile strength 22,000 lbs. per sq. inch and elongation of 3 per cent. in 2in. gave after heat treatment 47,000 lbs. per sq. in. ultimate strength and 14.5 per cent. elongation in 2in. A full technical account is given of the methods of preparing the alloy for casting, the crucibles, frames, temperature control, addition of alloy, stirring, fluxing, etc. The elongation yield point and ultimate strength are shown graphically as functions of time of heat treatment. The results on fifteen different alloys are tabulated numerically. Four micro-photographs show corresponding changes in structure.

The erratic group results indicate that the conditions under which the best test properties are developed remain somewhat conjectural.

The Magnesium Industry. (J. A. Gann, Ind. and Eng. Chem., Vol. XXII, No. 7, July, 1930, pp. 694-700.) (10.2102/13221 U.S.A.)

A concise account is given of the occurrence of magnesium in the earth's crust, methods of commercial production, and consumption in the United States. Since 1915 consumption has increased about tenfold, to 900,000 lbs., and the price per lb. has fallen from 20/- to about 2/- per lb. The resistance of the metal to atmospheric corrosion is considered to be equal to that of other common engineering metals, particularly after eliminating electro-negative heavy metals as impurities. The principal application is in pyrotechnics, but recently its value as a constituent of light alloys, particularly for aeroplane work, has become recognised. The properties of cast and wrought pure magnesium and a 7 per cent. aluminium alloy cast, with and without heat treatment, and wrought, are tabulated. Other tables give comparisons with other metals and alloys, both by sectional area and by weight.

Use of Light Alloys in Air-Cooled Radial Engines. (F. Gosslau, Z. Metallk., Vol. XXI, No. 7, July, 1930, pp. 224-227.) (10.23/13222 Germany.)

A number of photographs and sectional sketches of types of cylinder are given. The flow of heat is discussed and measured temperature gradients are shown across five sections of four types of cylinder fitted with light alloy cooling fins. A photograph is given of the Siemens radial 600 h.p. engine, and a diagram of performance and fuel consumption.

Attacks of Insects on Metals. (O. Bauer and O. Vollenbruck, A. Metallk., Vol. XXII, No. 7, July, 1930, pp. 230-233.) (10.27/13223 Germany.)

A number of cases are cited from other authors, chiefly with reference to attacks by beetles on leaden pipes and cable coverings. Original observations are given with photographs of the damaged specimens and of the insects.

Lead is by far the commonest object of attack, but specimens of tin bored through are shown.

Timber

The Artificial Seasoning of Timber. (I. F. Moll, Z.V.D.I., Vol. LXXIV, No. 11, 15/3/30, p. 343.) (10.32/13224 Germany.)

In drying timber circulation of the air round the wood is of extreme importance. The process of drying is largely one of diffusion and the rapidity of drying does not depend on the absolute quantity of water present, but rather on the distribution of the water on the diffusion velocity curve. To remove the last traces of water requires great vapour pressure differences and consequent risk of fracture. Rapid methods of drying are wasteful of material. To reduce the water content of a 2in. beam, weighing 655 kg./m.^{3}, from 27 to 8 per cent. requires six days. To dry it in one day, as was American practice till recently, is dangerous.

A Wood-Metal Material. (Instrument World, August, 1930, p. 99.) (10.4/13225 Germany.)

A new process is described by which it is possible to fill the pores of wood with metal. The material produced combines the properties of both the wood and the metal. The process consists of plunging the wood, either in a natural or prepared state, into molten metal and then subjecting to pressure. It is claimed that this new material can be machined like ordinary wood, that it takes fire with difficulty, and does not swell from absorption of moisture.

Ice Formation

Refrigerated Wind Tunnel Tests of Surface Coatings for Preventing Ice Formation. (M. Knight and W. C. Clay, N.A.C.A. Tech. Note, No. 339, May, 1930.) (10.46/13226 U.S.A.)

The conditions of ice formation were reproduced and a number of substances were tested as coatings. The substances were classified as soluble in water and insoluble in water. The latter were found to be ineffective. Positive results are therefore restricted to the soluble compounds. These in turn are divided into soft soluble compounds and hard soluble compounds. The former blew away from the leading edge and did not prevent the growth of ice. The latter, adhering strongly to the surface prevented ice formation within certain temperature limits according to their solubility.

Coatings need be applied only to the leading edge and surface as far back as the maximum co-ordinate.

It is suggested that a continuous supply of liquid compound soluble in water to the leading edge might prove an effective method. A good deal of light is thrown on the mechanism of the formation of ice, and photographs illustrate various stages.

Ice Formation on Wings. (U.S. Air Services, April, 1930, p. 23.) (10.46/13227 U.S.A.)

Oil or grease covering is not always effective in preventing ice formation. Heating the wings adds considerable weight and has not yet been tried. At present the pilot should keep clear of air conditions where ice is liable to form. Ice warning indicators are available and should be valuable guides.

Materials, General, Strength, Etc.

Studies in Vulcanisation of Rubber. (J. T. Blake, Ind. and Eng. Chem., Vol. XXII, No. 7, July, 1930, pp. 737-771.) (10.52/13228 U.S.A.)

(i) The heat of vulcanisation of rubber by sulphur has been determined over the whole range of combinations. The formation of hard rubber is strongly exothermic, but soft rubber is formed without heat interchange.

(ii) The vulcanisation of rubber with nitro-compounds is discussed and a physical chemical theory is put forward; soft rubber only is yielded.

(iii) The rates of combination of selenium and rubber have been determined and empirical equations obtained in linear form, giving on integration a logarithmic relation which predicts results hitherto considered anomalous.

(iv) Previous theories of vulcanisation are reviewed and a modified theory proposed. An application is made to the process of reclaiming rubber and explains the progressive deterioration of the reclaimed article.

Stresses in Heavy Helical Springs. (E. Latshaw, Jrnl. of Franklin Inst., Vol. CCIX, No. 6, June, 1930, p. 791.) (10.57/13229 U.S.A.)

Improved elementary formulæ are developed which give approximate stresses by superposition.

The maximum stress is found at a point inside the material. Consequently signs of fatigue may be concealed until failure occurs.

Physics and Metallurgy. (W. Rosenhain, Z. Metallk., Vol. XXII, No. 3, March, 1930, pp. 73-78.) (10.6/13230 Germany.)

The relation of molecular physical theory to the properties of metals is surveyed and illustrated by typical lattice diagrams.

Stresses in Ties and Struts Under End Constraint. (W. H. Brooks, Phil. Mag., Vol. VIII, No. 57, March, 1930, p. 426 (Part II), and No. 61, June, 1930, p. 1094 (Part III). 10.605/13231 Great Britain.)

See also abstract No. 12/11604. As for the former problems, differential equations are formed and solved for new problems, and charts are drawn for their determination.

Tests on Short Bolts in Wooden Structural Members. (A. Teichmann and K. Borkmann, L.F.F., Vol. VIII, No. 1, 24/5/30, pp. 18-38, 179th Report of D.V.L.) (10.605/13232 Germany.)

The research is a continuation of the work in L.F.F., Vol. II, 1929, page 147, and D.V.L. Year Book, 1929, p. 135.

A single bolt with sufficient clearance to avoid friction and so short in relation to its diameter that its deformation is negligible passes through the timber specimen at right angles to the fibres.

The lack of homogeneity in the timber raises a number of problems as to the comparative value of the tests, *e.g.*, the differences between heart and sap wood, between trunk and branch, the effects of the position of the bolt relative to the rings, the influence of the boundary distance, of the width, of the type of loading, of moisture, etc.

The details of the mounting of the tests are fully explained and exhibited in diagrams, and sources of error are discussed. Numerous stress-strain diagrams are reproduced of tests up to rupture, and photographs of ruptured pieces are given.

Mean values of the shearing strength and compression strength are given for Scotch fir, silver fir, spruce, ash, alder, birch, copper beech, and birch plywood.

Sap wood was from 5-20 per cent. weaker than the heart, and quantitative estimates are given for the effects of the different conditions stated above; in particular an increase of moisture from 12 per cent. to 33 per cent. diminished the strength by about 40 per cent. Eight references are given.

Buckling Strength Under Shear of Sheet Metal with Stiffening Ribs. (C. Schmieden, Z.F.M., Vol. XXI, No. 3, 14/2/30, pp. 61-65.) (10.605/13233 Germany.)

Cross ribs only are considered in the first place.

Simplifying assumptions are made and the partial differential equation of elastic bending is formed. On the assumption of small deformations the equations become linear and are solved in the usual way. The boundary conditions are introduced and after further approximations numerical solutions are obtained for particular cases.

For diagonal loads a similar method is followed and analogous results are obtained.

Finally the case of both cross and longitudinal stiffeners is worked out with the further modification of the numerical coefficient in the expression for the buckling load. The conditions for minimum material under a given load are worked out numerically.

Advances in Fatigue Limit Research since 1929. (H. F. Moore, Meeting of the American Iron and Steel Institute, Z.F.M., Vol. XXII, No. 2, Feb., 1930, p. 55.) (10.621/13234 Germany.)

For many working substances there exists an upper load limit below which the specimen will not break for milliards of reversals. Short time methods of fatigue testing have not been found reliable. A method depending on electrical conductivity is considered to be more promising. The term " fatigue " fracture

is misleading. From the moment of solidification, before external stresses are applied, the metal is internally stressed by the presence of ultra-fine cracks.

Testing Methods, Apparatus and Instruments

The Wind Tunnel as an Engineering Instrument. (A. L. Klein, S.A.E., Vol. XXVII, No. 1, July, 1930, pp. 87-90.) (11.16/13235 U.S.A.)

The applications and limitations of the wind tunnel are briefly stated and discussed.

Inspection of Metals and their Alloys. (L. W. Johnson, Jrnl. R. Aer. Soc., Vol. XXXIV, No. 234, June, 1930, pp. 441-494.) (11.24/13236 Great Britain.)

The author discusses the whole range of tests methods, and gives tables and graphical charts and photographs of test pieces. The origins of various defects in ingots, forgings and working parts are discussed. The correlation of Brinnell tests with other qualities is considered carefully. Directions are given for pickling and etching specimens of steels and non-ferrous alloys.

Application of X-Rays to the Study of Metals. (J. B. Friauf, Rev. Sci. Insts., Vol. I, No. 7, July, 1930, pp. 361-396.) (11.26/13237 U.S.A.)

A descriptive and elementary geometrical account is given of the reflection and refraction of X-rays from crystals.

Photographs of reflection and refraction patterns are reproduced. Forty-one references are given.

New Power Torsionmeter. (Instrument World, Aug., 1930, p. 99.) (11.27/13238 Great Britain.)

A new apparatus is described for measuring torsion of shafts under load. The principle used is the elongation of a steel thread stretched along the shafting and fixed by two brackets which are themselves fixed to two wrought iron rings on the shafting at a definite distance from each other. The thread is made to vibrate by an electro magnet in the neighbourhood and the vibrations set up an alternating current in another electro magnet. Frequency varies with the variation of length of the thread which is produced by fluctuations in torsion of the shaft. This current actuates a loud speaker telephone at a distant observation station in which a similar system is provided. The thread in this latter system is stretched by a micrometer screw and accordingly its length and load are correctly known.

Airships, Etc.

Some Details of the Next Zeppelin. (Airc. Eng., Vol. II, No. 16, June, 1930, p. 153.) (12.13/13239 Great Britain.)

It is stated that these details were given by Dr. Eckner during his recent visit to London.

Transverse Frames of Rigid Airships. (H. M. Lyon, Jrnl. Royl. Aer. Soc., Vol. XXXIV, No. 234, June, 1930, p. 497.) (12.2/13240 Great Britain.)

The methods of calculations were developed by the author when a member of the technical staff at R.A.W., Cardington. A large number of formulæ are worked out for different conditions of loading, the transverse being treated as separate from the longitudinal frame.

Although not a complete solution of the problem the bringing together of a large number of worked out partial problems is useful for the designer.

Modern Airship Ports. (D. Breithaupt, Ill. Flugwoche, Vol. XI, No. 10, Oct., 1929, Supplement.) (12.4/13241 Germany.)

The lay-out of an airship port for modern requirements is discussed. Various suggestions are made for pivoting the whole shed in the direction of the wind. Alternatively a combined system of pivoted, movable and fixed sheds enables the airship after landing in a pivoted shed to be transferred to a fixed one.

Operation and Construction of Kite Balloons. (W. Kamm, L.F.F., Vol. VI, Part 3, 10/2/30, pp. 61-86.) (12.5/13242 Germany.)

The date of the original paper is 20/12/21, but the matter is thought worth publication. References are given to previous work. Formulæ are developed for the attainable height, taking into account wind pressures and giving the drag on the mooring rope at different wind speeds.

Various types are described and numerical values are given from which it appears that the English type possesses considerable advantages. Certain disadvantages are considered and improvements are suggested.

Stability is discussed and diagrams of moments are given for a usual type of mooring. The whole subject is examined numerically, including practical tests of the English type and of a selected German type.

It is concluded that the principles of correct design have been established. Five photographs of the German K balloon in various attitudes are given.

Comparison between Riedinger (German) and Caquot (French) Captive Balloons. (Rev. F. Aer., Feb., 1930, pp. 210, 218.) (12.5/13243 France.)

The French Caquot observation balloon has the point of attachment relatively far from the centre of gravity, involving a high incidence in strong winds. The German Riedinger balloon has a better shape and attachment giving less incidence. The rate of hauling down is twice that of the Caquot, and in a high wind the drag on the cable is one quarter.

The First Inflation of the R.100. (P. L. Teed, Aire. Eng., Vol. II, No. 16, June, 1930, p. 135.) (12.61/13244 Great Britain.)

An account is given of the technical, chemical, thermal, operational, and financial factors entering into the problem of hydrogen production on the large scale required.

Present Position of Helium Supply and Research. (H. Beelitz, Z.F.M., Vol. XXI, No. 5, 14/3/30, pp. 109-115.) (12.62/13245 Germany.)

The sources of supply in the United States are described, with statistics of the available quantities.

The possibility of combining power gas and lifting gas in the same hull with a minimum of fire risk is discussed.

The chemical and physical properties of helium are briefly considered.

Wireless

Japanese Radio-Frequency Standard. (Y. Namba, Proc. Inst. Rad. Eng. (U.S.A.), Vol. XVIII, No. 6, June, 1930, p. 1017.) (13.0/13246 Japan.)

A descriptive account is given of the laboratory equipment whereby a standard frequency of nearly 1,000 cycles per second at 36°C. was maintained, with an accuracy of a few parts in a million.

Air Transport Communication. (R. L. Jones and F. M. Ryan, Bell Tele. Lab., No. B.478, May, 1930.) (13.1/13247 U.S.A.)

A number of test curves are given of signal strengths against distance, which apparently fall off with height as well as distance. A number of wiring

diagrams are given for the standard apparatus established in the United States. Photographs are given of assembled apparatus and of the method of using mouth and earpieces.

Radio Facilities for Aircraft Communication. (E. L. Nelson and F. M. Ryan, Bell Tel. Lab., No. B.471, May, 1930.) (13.1/13248 U.S.A.)

Photographs are given of sets designed for aircraft communication, with brief specifications, diagrams of connections on aircraft and test curves of signal strengths. Shielding of the ignition system is discussed and illustrated by two photographs. (See also No. 14/12872.)

Meteorological Influences in Reception in Japan. (E. Yokoyama and T. Nakai, Proc. Inst. Rad. Eng. (U.S.A.), Vol. XVIII, No. 6, June, 1930, p. 1075.) (13.1/13249 Japan.)

Reception at wave lengths of 10,000 to 20,000 m. from distances of 3,000 to 11,000 km. were studied, and monthly averages were plotted from 1926 to 1928. It is inferred that the field intensity varies inversely as the atmospheric temperature on the receiving side, not only for monthly averages but for daily variations; but the true meteorological causes and effects are not considered to be established.

Amplification and Rectification of Electron Tubes. (N. Vermes, Ann. d. Phys., Vol. IV, No. 7, May, 1930, p. 943.) (13.1/13250 Germany.)

From author's summary:—Diagrams of the connections of the experimental apparatus are given. The data of the tube are based on determinate steady values. When an additional electromotive force is excited in the grid circuit the data are determined by a new set of steady values. The change in the anode voltage appears as a quadratic function of the additional grid voltage; the coefficient of the linear term is the amplifying factor, the data of the tube and of the external circuit appearing in the expressions. The formulæ give the amplification and rectification, the latter being additive. From the general formulæ for amplification and rectification well-known particular cases are derivable. The formulæ were checked by a series of experiments.

Reflection of Long Electro-Magnetic Waves from the Upper Atmosphere. (D. Burnett, Phil. Mag., Vol. X, No. 62, July, 1930, pp. 1-17.) (13.5/13251 Great Britain.)

The solution of the problem of the reflexion of long electro-magnetic waves from the upper atmosphere has been solved on the assumptions that the earth is a perfectly conducting sphere and that the concentric spherical surface divides the atmosphere into two parts, each homogeneous. The method is satisfactory for short wave lengths. In the present paper the method is generalised and an exact solution is found in Bessel functions in a form suitable for computation.

(*i*) *Simultaneous Observations on Downcoming Wireless Waves.* (E. V. Appleton and J. A. Ratcliffe, Proc. Roy. Soc., Vol. CXXVIII, No. A.807, pp. 133-158.)

(*ii*) *Short Wave Equivalent Height Measurements of the Ionised Regions of the Upper Atmosphere.* (E. V. Appleton and A. L. Green, ditto, pp. 159-178.) (13.5/13252 Great Britain.)

(i) Measurements were made on the equivalent height of ionised layers of the atmosphere reflecting signals between 200 and 500 metres wave length over distances of 18 km., 91 km. and 131 km. Two reflecting layers were determined at heights of 200 and 110 km. respectively. The lower layer is only effective during daylight.

(ii) In the second article determinations were made with wave lengths of the order of 100 metres. Results are applied and compared with previous measurements. Generally speaking, the shorter waves penetrated further into the ionised layers before being deflected than longer waves. The variations from night conditions to day conditions and diurnal fluctuations are discussed.

Single and Coupled Circuit Systems. (T. S. Purington, Proc. Inst. Rad. Eng., Vol. XVIII, No. 6, June, 1930, p. 983, p. 1016.) (13.5/13253 U.S.A.)

From author's Summary :—Transmission equations are developed and it is shown that for a desired possible transmission-curve shape, the sum of all decrement coefficients must be a certain amount, readily computable for coupled circuits as well as for single circuits.

Coupled circuit transmission-curve shapes may be developed from single-circuit curves by a multiplication process as in staggered-cascade amplification, or by a vector difference process, employing two staggered single circuits with opposite couplings from a power source.

Complex networks are handled by transfer equations by which a branch consisting of a voltage source and resistance in series coupled to a network by a transformer device is replaced by an equivalent voltage and impedence within the network.

Theory of the Radiation Coupling of short Wave Aerial Systems. (R. Bechmann, Ann. d. Phys., Vol. IV, No. 7, May, 1930, p. 289.) (13.7/13254 Germany.)

From author's summary :—The system consists of an arbitrary arrangement of parallel conductors, some of which are directly excited by an external e.m.f., while the remainder are excited only by radiation coupling. In the mathematical discussion a system of differential equations of the ordinary vibrational type is formed, the number of equations being equal to the number of conductors. Damping is introduced through Planck's frictional force. The induced electrical field between pairs of radiating conductors is derived in closed form from the Hertz vector.

The coupling forces and the Fourier coefficients are calculated from the characteristic functions of the emitters and are explicitly determined for the fundamental period of the emitters.

The solution of the system gives a simple method of calculating the radiating resistance even of complicated systems of antennæ, in particular for projector antennæ as applied in short wave technique. An example is worked out for emitters excited in phase.

An example of an antenna with an unexcited conductor-reflector is discussed. The best distance between antenna and reflector and the maximum radiation in the principal direction are calculated.

Eighteen references are given.

Effect of Rain and Fog on Propagation of Very Short Waves. (J. A. Stratton, Proc. Inst. Rad. Eng., Vol. XVIII, No. 6, June, 1930, p. 1064.) (13.7/13255 U.S.A.)

The expression of the Poynting Vector in the radiation field of a scattering particle regarded as a dipole is written down and summed over a unit volume. The polarisation is given by the Lorenz formula. Integrating over unit sphere, the total energy scattered is obtained. On developing the expression numerically it is found that the scattering of waves longer than 5 cm. is negligible.

Radio-Telephony on Half-Metre Waves. (S. Uda, Proc. Inst. Rad. Eng. (U.S.A.), Vol. XVIII, No. 6, June, 1930, p. 1045.) (13.7/13256 Japan.)

A description is given of a new receiver for waves of 40 to 80 cm., with photographs and diagrams of connections. Characteristic curves are plotted graphically, and in particular, the audibility of directed waves at 10 km. was tested. A sharp damping with a divergence of a few degree in every plane was obtained.

Photography and Aerial Survey

Air Photography Surveys. (J. Durward, Jrnl. R. Aer. Soc., Vol. XXXIV, No. 232, April, 1930, p. 344.) (14.1/13257 Great Britain.)

A descriptive account is given of the requirements of a photographic survey. Different types of photograph are classified and the difficulties of interpretation are discussed. Flying organisation and ground organisation require the closest attention to achieve results of any value. In particular ground survey parties must prepare the necessary check points for the reduction of photographs. The great advantage of the air photograph is the refinement, which no ground survey could possibly supply.

Aerial Photography. (Aviation, Vol. XXVIII, No. 19, 10/5/30, p. 952.) (14.21/13258 U.S.A.)

A long-distance camera developed by the experts of the Air Corps photographic section obtained a photograph of Mount Ranier, 14,500 feet high, at a distance of 270 miles, from an aeroplane at a height of 20,000 feet. The lens, of a deep red colour, acts as a light filter. A specially sensitive film was used.

New Ultra-Speed Kinematograph Camera taking 40,000 Photographs per Second. (T. Suhara, Aero. Res. Inst., Tokyo, Rept. No. 60, May, 1930, 15 pp.) (14.6/13259 Japan.)

By means of a rotating mirror, illumination can be interrupted at a much greater frequency than by any type of mechanical shutter.

Sectional sketches are given of two types, one giving 20,000 illuminations per second and the other 40,000.

Five examples of films are shown:—

A stream of hot air cut by a two-bladed airscrew; frequency 10,000 per second.

Sound waves in a circular cylindrical shell, source at axis; frequency 40,500 per second.

Sound waves in a circular cylindrical shell, source eccentric; frequency 30,000 per second.

Sound waves in an elliptical cylindrical shell, source at focus; frequency 31,500 per second.

Sound waves in an elliptical cylindrical shell, source not at focus; frequency 40,500 per second.

Determination of the Trajectory of a Target Moving in Space by Means of Askanio Kino-Theodolite. (R. Leonhardt, Z.V.D.I., Vol. LXXIV, No. 11, 15/3/30, pp. 347-349.) (14.6/13260 Germany.)

This instrument is intended for precision recording of aircraft motions. The exposure time is of the order of 3/1000 sec., five exposures being made per second. The film showing the aircraft gives the azimuth and elevation of the theodolite and the time of each exposure. The combined use on a base line of two instruments, the motion of both films being controlled by a master timing device, gives the trajectory of the aircraft in space.

Anti-Aircraft Ranging and Gunnery

A 75-mm. Field Gun. (G. M. Barnes, Army Ord., Vol. X, No. 60, May-June, 1930, p. 391.) (15.21/13261 U.S.A.)

The trail and mounting are carried by a trailer truck with two pneumatic tyred double wheels; the truck is detachable and the trail spreads out into four separate arms at 90°, when the weapon is ready for service as a field or anti-aircraft gun at an elevation of 80° and a traverse of 30°. Muzzle velocity 2,175 ft. per second, maximum range 15,000 yards, 15 lbs. projectile.

Photographs and sketches illustrate the general arrangement.

Parachutes

Regulations for Parachutes. (Aviation, Vol. XXVIII, No. 25, 21/6/30, p. 1226.) (16.11/13262 U.S.A.)

A summary is given of regulations issued by the Assistant Secretary of Commerce for Aeronautics. Parachutes must satisfy five tests carried out over twenty drops from an aeroplane in flight.

(1) Time of opening ... ... 3 secs.
Weight of dummy ... ... 170 lb.
Aeroplane speed ... ... 70 m.p.h.
Height ... ... 500 ft.

12 drops.

(2) With suspension lines twisted.
Time of opening 4½ seconds; other conditions as before.

Five drops.

(3) Weight of dummy ... ... 600 lbs.
Speed of aeroplane ... 100 m.p.h.
Height ... ... 500 ft.

(4) Two drops with a man of 170 lbs. weight from a height of 2,600 feet.

(5) One drop from 2,500 ft. with dummy 170 lbs. Rate of descent not to exceed 21 ft. per second.

Automatic Parachutes. (Flugsport, Vol. XXII, No. 13, 25/6/30, pp. 224-226.) (16.11/13263 Germany.)

An account is given of the fatal accident to Nehring during a gliding flight, caused by the breaking of a wing of his high performance glider. His passenger was thrown clear and was saved by the automatically opening parachute. The occasion is used to advocate the use of parachutes of this type.

Accidents

Safety in Flying. (Tech. Aeron., Vol. XXI, No. 104, June, 1930, pp. 122-128.) (16.2/13264 France.)

The subject is reviewed by the head of the Inspection Department of the French Air Ministry. Accidents during 1928 are tabulated and the causes are analysed.

Aircraft Failures: Influence of Power Plant Weight on Aircraft Performance. (M. Schrenk, L.F.F., Vol. VI, No. 4, 14/2/30, pp. 92-96, 157th Report of D.V.L., read at D.V.L.) (16.2/13265 Germany.)

A graphical chart shows the relative number of accidents due to failure of structure, engine, piloting, external influences, faulty maintenance, and a small miscellaneous balance.

There is a distinct tendency towards an increase in proportion of engine failures. The relations between performance and power plant weight, structural weight, aerodynamical qualities, range and loading are briefly discussed by the author and by a number of members present.

Deck-Landing and Take-Off

Catapults. (L. D. Webb, Air Services Mag., Vol. XV, No. 7, July, 1930, pp. 21-26.) (18.4/13266 U.S.A.)

A descriptive account is given of the equipment and operation of catapults in projecting aircraft from shipboard. Three photographs are given.

Ship to Shore Air Mail Service. (C. H. Gale, Aviation, Vol. XXVIII, No. 22, 31/5/30, p. 1084.) (18.4/13267 U.S.A.)

An account is given of the operation of catapult launching of mail-carrying seaplanes from French and German liners.

Considerations Affecting Pilots

Light Metal Oxygen Bottles for Portable Breathing Apparatus. (Z. Metallk., Vol. XXI, No. 7, July, 1930, pp. 235-237.) (19.12/13268 Germany.)

Official specifications and tests are given along with two photographs of ruptured bottles. Details of dimensions and test results are given in five tables. The question of corrosion is also considered.

Estimations of the Maximum Attainable Muscular Force and Velocity of Application in Aeroplane Controls. (Z.F.M., Vol. XXI, No. 2, 28/1/30, pp. 36-45, 169th Report of D.V.L.) (19.2/13269 Germany.)

The lay-out of the experiments and the experimental equipment are described. Records were made of repeated control efforts exerted by eleven pilots and students of different ages, weights and heights. The numerical results are given in elaborate tables, and are valuable in designing controls for the maximum effort likely to be exerted.

The effects of fatigue are clearly shown.

Miscellaneous Abstracts

Economics of Air Transport. (A. Koyemann, Luftfahrt, Vol. XXXIV, No. 3, March, 1930, p. 83.) (13270 Germany.)

A scheme of costing formulae is given with numerical values of the details in a particular example. The possibility is discussed of rendering air transport undertakings remunerative.

Air Transport between North and South America. (W. I. VanDusen, Air Services Mag., Vol. XV, No. 7, July, 1930, pp. 29-35.) (13271 U.S.A.)

Some statistical and technical equipment details are given of the air routes in South America and the connecting air routes with North America, illustrated by a map. Photographs are given of two seaplanes operating between Buenos Ayres and the States.

The Training of Commercial Pilots in Germany. (R. M. Mock, Aviation, Vol. XXVIII, No. 22, 31/5/30, p. 1080.) (13272 U.S.A.)

From among 700 to 1,000 applicants each year 70 to 80 are selected for a preliminary course of four weeks, and a final selection of about twenty-five remain to continue the course. A complete account is given of the equipment

and training courses. The losses are given as one seaplane total loss in 600 flying hours, and one land plane lost in 2,000 flying hours. The proportion of minor accidents is much greater with land machines. Some figures of cost are given.

Problems of Arctic Flying. (H. Wilkins, Aviation, Vol. XXVIII, No. 22, 31/5/30, p. 1076.) (13273 U.S.A.)

A descriptive account is given with a number of technical and economic details of problems that arose during various arctic and antarctic expeditions.

Aircraft Materials. (American Society for Testing Materials, Philadelphia.) (13274 U.S.A.)

The following papers, prepared for reading at the Thirty-third Annual Meeting (June, 1930) are printed in the form of a Symposium :—

Personnel of Advisory Committee.
Ferrous metals used in airplane construction. J. B. Johnson.
Structural and engineering light alloys for aircraft. R. L. Templin, F. V. Hartman and E. C. Hartmann.
Strength and characteristics of wood used in aircraft construction. G. W. Trayer.
Aeronautical textiles. W. E. Emley.
Corrosion prevention methods as applied in aircraft construction. H. S. Rawdon.
Notes of aircraft finishes. H. H. Gardner.
Materials of construction in aircraft engines. R. R. Moore.
Failures of aircraft engine parts and causes thereof. T. T. Neill.
Mechanical testing of aircraft materials. J. B. Johnson.
Metal joints in aircraft construction. T. Watson Downes.
Procedure control in aircraft welding. H. L. Whittemore, John J. Crowe and H. H. Moss.
X-ray testing of aircraft materials. Ancel St. John.
Photo-elastic studies of aircraft parts. T. H. Frost.

REVIEWS

The R.A.F. Quarterly, October, 1930

This, the fourth number of the *Royal Air Force Quarterly*, keeps up the extraordinary high standard which was set with number one. It has an Empire outlook and there are articles dealing not only with progress in the Air Force as we know it here, but with progress throughout the Empire. One may name two articles in this connection, "Western Samoa Operations, 1930," by Flt. Lt. S. Wallingford, of the New Zealand Air Force, and "Civil Aviation in New Zealand," by J. T. Crawford. Mr. J. M. Spaight, who is probably the greatest authority on his subject, despite the many criticisms which have been levelled at him from time to time (and criticism of authority is a very healthy sign), writes on an "International Air Force." Other articles of importance to those joining the Royal Air Force are the "Personal Factor in Flying and the Influence of Flying on Character," by Wing Commander A. G. R. Garrod, the energetic Secretary of the Oxford Branch of the Society, and "Some Notes on Preparing for the Staff College," by Wing Cmdr. R. Graham. Mr. C. J. Stewart has an article on "Cloud and Fog Flying," which is perhaps one of the most important problems with which we have to deal at the moment. As befits a service which cannot be always serious (as witness the side shows at the Pageant), the *R.A.F. Quarterly* very rightly devotes each month a certain amount of its space to light verse and short stories. Even civil aviation is included, and here the reviewer feels very strongly that the right course has been taken as so many of the Royal Air Force personnel must naturally be absorbed ultimately by the civil side of aviation. There is not only a review of "Civil Aviation Developments," by Major C. C. Turner, who is perhaps one of the oldest and most experienced of the writers on aeronautics, but there are other civil aviation notes on various parts of the Empire. As usual the *Quarterly* in its format leaves nothing to be desired.

Die Rakte für Fahrt und Flug

By A. B. Scherschevsky. (C. J. E. Volkmann, Berlin-Charlottenburg.)

Quite a number of books, mostly of the popular type, and novels on the subject of travelling through space, have appeared in Germany recently, culminating in the production of a film, now being shown in England ("The First Woman in the Moon"). The book under review is intended for readers having a general knowledge of mathematics and physics. In the first sections the author develops the theory of the rocket from the energy standpoint, and calculates the initial acceleration required to carry a rocket machine working at its maximum thermal efficiency beyond the sphere of the earth's gravitation. Next the best aerodynamic shape for the machine is discussed and it is shown that the machine should take the form of a tailless glider. The latter part of the book consists of a history of the development and the idea of space-travel, and the practical work which has been carried out on rockets and rocket engines up to the year 1929. The volume concludes with a very complete bibliography.